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THE DENVER, NORTHWESTERN AND PACIFIC RY.

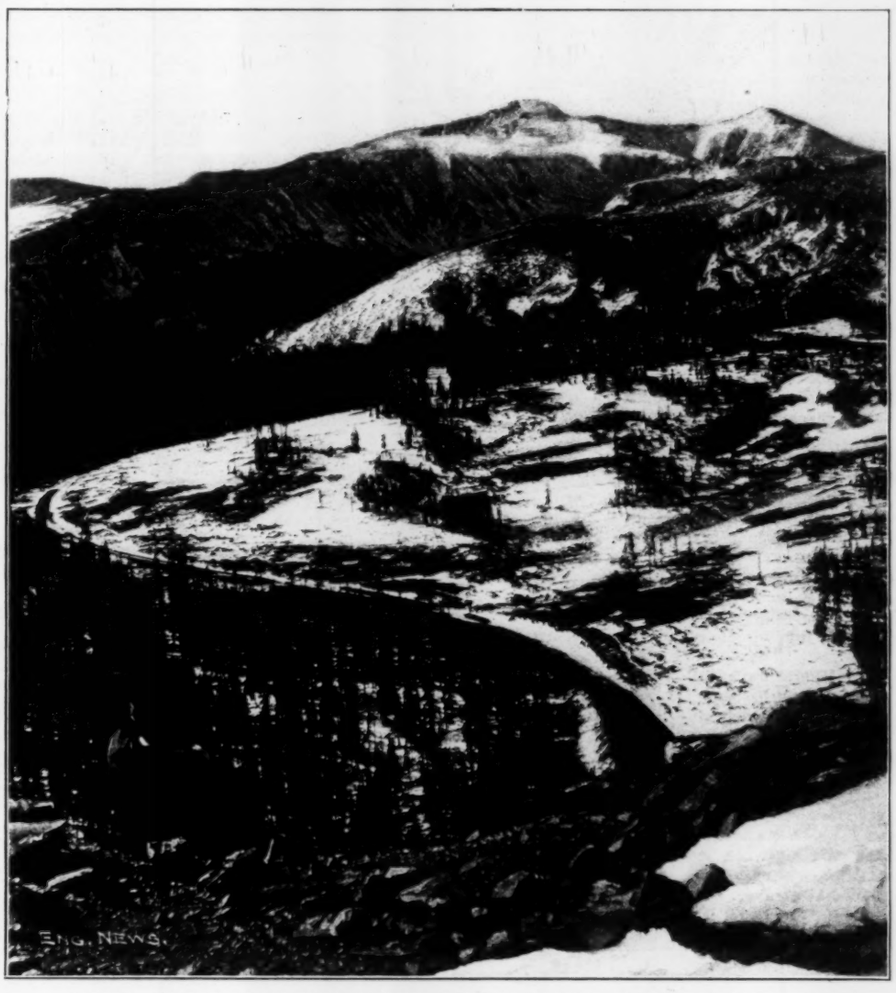
By W. P. Hardesty, C. E.*

During the past two years there has been under construction a railway, which will not only afford an important cut-off in the central transcontinental route to the Pacific coast, but which will at the same time traverse a section of country, undeveloped by railroads, which is probably larger than any similar area to be found in the United States.

The major portion of the obstructions interposed by mountains to the building of a railway from the plains country of Colorado (by the central route) to the coast, are found between the eastern foot-hills of Colorado and the central valleys of Utah.

There are, at present, two lines of railway connecting Denver, Colo., with Ogden and Salt Lake City, Utah. Both these are far from direct. The Union Pacific runs nearly north for 107 miles from Denver to Cheyenne, Wyo., then runs westerly through southern Wyoming and on to Ogden, Utah, a total distance of 591 miles. It is 36 miles farther on south to Salt Lake City. The Denver & Rio Grande runs east of south, from Denver to Pueblo, 119 miles, before turning westerly. The distance by this route from Denver to Salt Lake City is 741 miles. Now the air line distance from Denver to Salt Lake City is only about 370 miles. The latter city lies 70 miles farther north than Denver. With the exception of a few short lines of railway run into the area enclosed by these two roads, from the east and west ends, the entire intervening territory has never been invaded by the locomotive. It remained for a pioneer railroad builder of Colorado, Mr. David H. Moffat, to first inaugurate, on a sound basis, an undertaking to penetrate this virgin territory and at the same time shorten the distance by rail between Denver and Salt Lake City.

There is no better *natural* passage through the great Continental Divide of the Rocky Mountains than that taken by the Denver & Rio Grande Ry. (which follows the canon of the Arkansas River), until we go north into Wyoming, beyond the rugged part of the divide. The Front Range of the Continental Divide, that fronting the plains to the east, rises quite abruptly from the foot-hills, presenting a wall that is a very formidable barrier to the construction of a railway over it. It is cut much more deeply than elsewhere by the canyon of the Arkansas River, which affords a water-grade almost to the summit of the main divide, near Leadville. The lack of such a natural passage anywhere else in Colorado further north, makes necessary much skillful development, as well as very heavy construction work, to secure a road with reasonable grades and curves.



JAMES PEAK, FROM ROLLINS PASS. DENVER, NORTHWESTERN & PACIFIC RY.
(Altitude of James Peak, 13,250 ft.)

The Denver, Northwestern & Pacific Ry. Co. was organized July, 1902, by Mr. Moffat and associates, to build a standard gage railway from Denver to Salt Lake by the most direct route practicable, consistent with light grades and easy curvature. Surveys were begun in April, 1902, and construction was started (near the east end) in January, 1903. The road at the present time is constructed from Utah Junction, 3.2 miles west of Denver, for a distance of 50 miles of main line, or within 4.9 miles of the eastern portal of the main range tunnel. From this point, to advance the work as rapidly as possible, pending the construction of the main range tunnel, it was decided to construct what is known as the Rollins Pass Branch, a line with heavier grades and sharper curvature, over the Continental Range at a low pass, called Rollins' Pass, connecting with the main line again near Arrowhead Station. This has been done, and the entire length of road now constructed and in operation from Utah Junction to Arrowhead is 73.17 miles.

From Denver to Utah Junction, pending the construction of a line into the city, the trains operate over the Burlington & Missouri River R. R. (Lyons Branch).

The line is under contract and being constructed from Arrowhead westerly to Hot Sulphur Springs, the county seat of Grand county, Colo., a distance of 34 miles, or to M. P. 100.

From Utah Junction to Leyden Junction, at M. P. 12.9, the country is mostly the tapering slope leading out from the foot-hills. The maximum grade to here is 1.7%, but from this point to the main range tunnel there is a nearly continuous grade of 2%, compensated.

From near M. P. 18, it is necessary to develop the line along the side of the foot-hills, which are in the Dakota group of sandstone, and the red beds underlying that formation. The line traverses the slope of the mountains facing the

*228 Commercial Club Bldg., Salt Lake City, Utah.

plains, in a northwesterly direction, to the canyon of South Boulder Creek, and then turns west along its south side. At first far above the canyon bed, the fall in the creek is so rapid that after passing along about 10 miles of the canyon, the river is within a few feet of the grade of the railway. The line continues along the valley of South Boulder Creek, and the mountain valley or park further up, for a distance of 13 miles, and the work is much lighter. Here the line turns back to the north side of Boulder Park, and begins a hillside development in order to reach the main range tunnel portal. From M. P. 53.3, where the Rollins Pass Branch diverges, the route is fairly direct to the east portal of the tunnel through the Continental Divide. This tunnel, as projected, will be 2.60 miles long, and at an elevation of 9,930 ft. On the west slope, the line descends by a 2% grade, over a country requiring expensive work, through not nearly so rugged as most of that on the east slope. The distance to Arrowhead, via this main line through the range tunnel, will be 66 miles. From here the line descends into Middle Park.

From the plains on the east to Middle Park on the west, the region is one abounding with scenic points of interest. The main range, or Continental Divide, tunnel-site is about two miles north of the apex of James Peak. The elevation of this peak is 13,250 ft.; that of the crest of the range over the tunnel is 12,200 ft.

The accompanying table gives the distance from Denver and the elevation of all the stations on the present operated line, the west part of which is embraced in the Rollins Pass Branch. Distances are figured from the Union Depot at Denver.

Miles.	Station.	Elevation.
0.	Denver	5,170
3.2	Utah Junction	5,215
6.9	Ralston	5,268
12.9	Leyden Junction	5,687
17.8	Arena	6,162
22.4	Coal Creek	6,602
24.4	Plainview	6,783
31.5	Crescent	7,457
36.8	Gato	7,958
41.7	Rollinsville	8,367
47.0	Tolland	8,889
52.1	Ladora	9,380
53.3	E. Junc. of Rollins Pass Branch	9,482
55.9	Antelope	9,905
61.0	Jenny Lake	10,860
65.3	Rollins Pass	11,660
69.2	Loop Siding	10,980
73.5	Fawn Creek	10,158
76.8	W. Junc. (Arrowhead)	9,510

= 66 of main line.

GRADES.—The maximum grade is 2%, compention to the east portal of the tunnel through the main range, 45.3 miles, the grade is nearly consated on curves at the rate of .035 per degree. There is nothing exceeding 1.7% ascending till Leyden Junction is reached. From Leyden Junctinuous 2%, except for the easing up alongside the sidings. At these places the grade is reduced to 1%. The projected main range tunnel is at an elevation of 9,930 ft., the rise from Denver being 4,760 ft. The tunnel grade is 0.25% ascending from each portal to the center. From the west portal of the tunnel westerly for a distance of 15.9 miles, on to M. P. 76.7, there is a continuous descending grade of 2%, compensated, with the exception of the light grades through the sidings. From M. P. 76.7 to M. P. 79.7, at Tabernash, the grade varies from a 1.25% at the steepest, to a 1% at Tabernash. From Tabernash westerly the maximum grade is 1%, although from the fact that much of the line is in the valley of Grand River, the greater part of the line as far as Kremmling (M. P. 117) is not over 0.6%. The road as contemplated will have not to exceed a 1% maximum grade, and this for comparatively short stretches only, between Tabernash and the foot of the grade east of the Wahsatch Range. It is contemplated to use a 1.5% grade approaching the Wahsatch from the east, and a 2% grade descending from the top of this range (elevation 8,000) down to the Provo River Valley, near Heber.

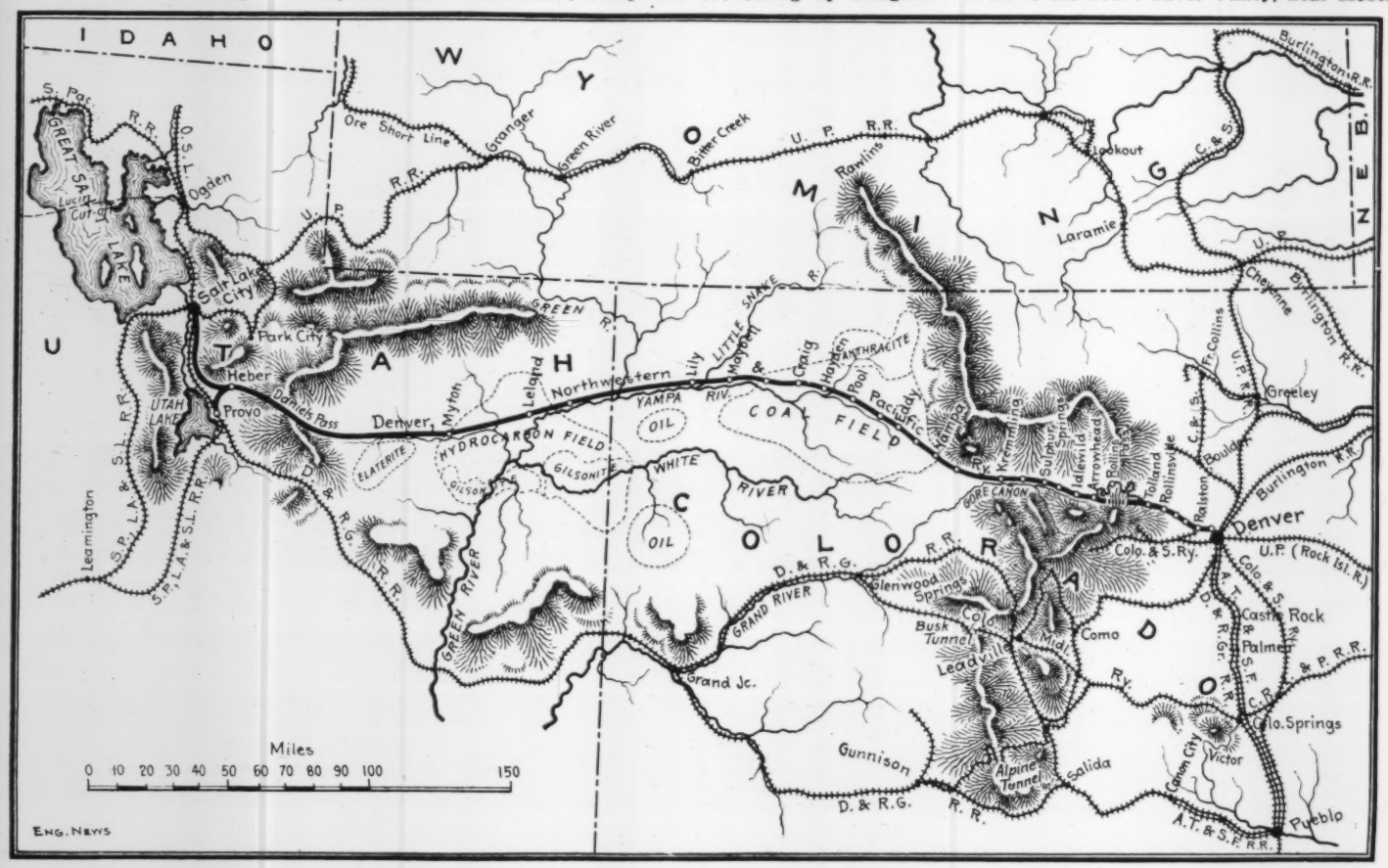


FIG. 1. MAP OF THE DENVER, NORTHWESTERN & PACIFIC RY., BETWEEN DENVER AND SALT LAKE CITY.

FIG. 3. DAY'S CAMP, ELEVATION, 11,760 FT.
Photograph taken June 6, 1904.
(The Summit on the Rollins Pass line is near this point and a little lower.)

CURVES.—The maximum curves are 10°. From Utah Junction on the present located line, to Hot Sulphur Springs, a distance of 97.28 miles, the total length of curved line is 42% of the entire distance, giving 132° per mile. Of this curvature 20.87% is between 1° and 5°; 10.20% between 6° and 8°; and 11.16% over 8°; 10.30% being 10° curves. All curves of 2° and over are spiraled, using Searles' formulae. For 10° curve, the length of the spirals is 10 chords of 18 ft.=180 ft. Where compound curves are instituted, if over 1° difference in ratio, a spiral is inserted between the two. A tangent of not less than 60 ft. is placed between ends of spirals on curves in opposite directions. Two curves in the same direction when within 500 ft. of each other are connected with a compound curve, to prevent a "broken back" alinement. Between Utah Junction and a point 17 miles out, no curve sharper than 3° is used, and in the valley of South Boulder Creek, near Rollinsville, the maximum is placed at 4°, thus enabling fast running over a large portion of the line east of the main range.

ELEVATION OF TRACKS ON CURVES.—The track is elevated by Searles' rules, a speed of 30 miles per hour (for passenger trains) being allowed on 10° curves, which latter require an elevation of about 6 ins.

VERTICAL CURVES.—No set rules are used for these. Nothing less than a change of grade

of 0.4% requires attention on the mountain division. When there is over a difference of 0.4% in grade rate, vertical curves from 400 to 600 ft. in length are used.

CONSTRUCTION OF ROADBED.—The roadway widths are 20 and 22 ft. in cuts for solid rock

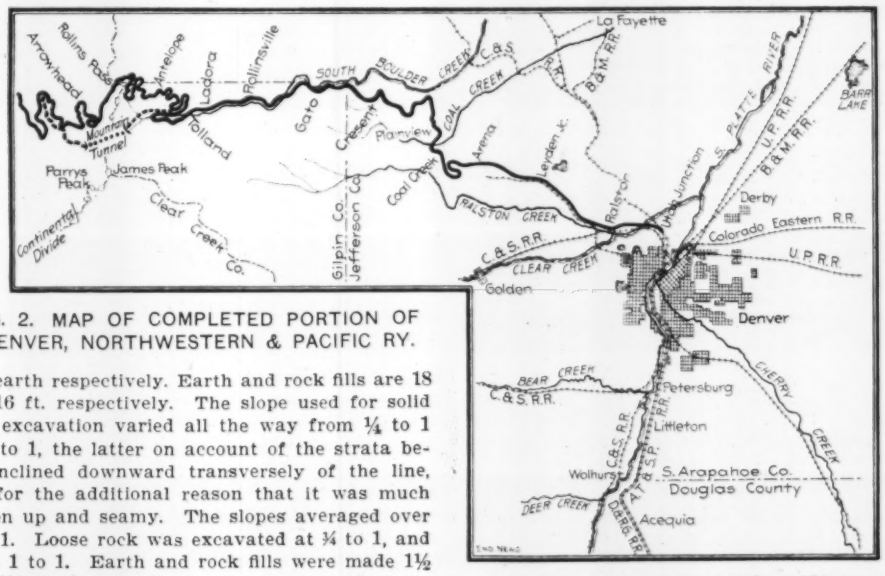


FIG. 2. MAP OF COMPLETED PORTION OF DENVER, NORTHWESTERN & PACIFIC RY.

and earth respectively. Earth and rock fills are 18 and 16 ft. respectively. The slope used for solid rock excavation varied all the way from ¼ to 1 to ¾ to 1, the latter on account of the strata being inclined downward transversely of the line, and for the additional reason that it was much broken up and seamy. The slopes averaged over ½ to 1. Loose rock was excavated at ¾ to 1, and earth 1 to 1. Earth and rock fills were made 1½ and 1¼ to 1 respectively, the latter taking the slope best suited to the material. The formation is all earth to near M. P. 20, at foot of the Front Range. Here the Dakota sandstone is encountered, in strata inclined downwards across the roadbed. After 5 miles of this there is about 6 miles of a broken and disintegrated granite. After this follows a harder, gray granite. This is nearly continuous to the summit of the Main Range but mixed along with it is considerable of the soft disintegrated granite. There is one point about 1,000 ft. in length where quartzite is found. The disintegrated granite has numerous talc seams through it, as has also some of the harder kind.

The line has numerous heavy cuts and fills. The heaviest excavations are in rock, and many have a cut on the upper side of 100 to 125 ft., with a yardage of 30,000 to 40,000. The heaviest fills are those that replace timber trestles. That across Quartz Creek, near M. P. 29 is 95 ft. high, and it contains 130,000 cu. yds., which is now filled. Taking the line already built, from Utah Junction to Arrowhead (which includes the surface line over the summit), only 8% of the grading has been in earth; 35% was loose rock, and 57% solid rock. The roadbed was given the proper elevation for curves in construction. The side ditches in cuts are each 4½ ft. wide on top, with bottom one foot below subgrade.

Slag from Denver smelters has been used in ballasting track from Utah Junction to a point 23 miles west; from this point west to Arrowhead, disintegrated granite and gravel ballast was used. The slag, which results from the smelting of ores in the smelters at Denver, makes a very good material. It is loosened up by blasting in the slag dumps, transported and unloaded at the required places, where all remaining over-sized lumps are broken by hand. The ballast is 10 ins. deep under the ties, and extends 18 ins. beyond their ends. Most of the permanent line has already been ballasted.

The ties are all Texas long leaf pine, 85% heart, 6x8 in. x8 ft. 80-lb. rails of the Am. Soc. C. E. section are used on the main line, on sidings and also on the Rollins Pass Branch. Tie plates are used on all ties, both on tangents and curves.

In providing for the drainage of the country, on the prairie section double-strength vitrified pipe is used under fills of 15 ft. and less. For higher fills, there is used a rock rubble, square box culvert, laid dry. On the mountain section, this box culvert is used, and also some cast-iron pipe. At Quartz Creek there are two lines of 36 in. cast-iron pipe, amounting to 602 ft. in total length. No masonry culverts have been used. All loose rock and earth cuts have surface ditches on the upper side, 3 ft. wide and 1½ ft. deep, leading down to the natural channels for passage under the track. They are usually placed 30 ft. back from the upper edge of the cut.

TUNNELS.—In the construction of this line, the location between M. P. 23.4 and M. P. 36.3 was on the sides of the foot-hills fronting the plains, and also high up above the bed of South Boulder Creek, owing to the development of a continuous grade to reach the main range tunnel elevation. In this stretch of 13 miles, owing to the rugged and broken nature of the country, and the prevalence of projecting points, between which were generally found deep gulches, in order to preserve a good alinement, such as was demanded, the engineer was met with the alternative of constructing high viaducts, and excavating heavy cuts, or else to lay the line on higher ground, and, to a large extent, eliminate the trestle work and substitute a number of tunnels. The latter form of construction was chosen, as giving a safe and more permanent roadbed, and more nearly conforming to the requirements of the high standard of construction demanded. In the 13 miles there are only two temporary wooden trestles, which will be filled by trains during this year. There are on this 13-mile stretch 30 tunnels, ranging from 73 to 1,729 ft. in length, and aggregating 16,000 ft. in all. The first 8 tunnels are in the sandstone formation, in the front range facing the plains; the remainder are in the water-shed of South Boulder Creek.

Beyond here, at M. P. 40.4, there is one tunnel of 255 ft., and on the located line approaching the main range tunnel there are three others aggregating 980 ft.

The normal section on tangent is 16 ft. wide, and 24 ft. high, or 22 ft. above top of rail in the completed track. On curves the width is increased, reaching 17½ ft. for a 10° curve, in which case the tunnel center is thrown 0.88 ft. toward inside of curve, to preserve the proper clearance

FIG. 4. PASSENGER TRAIN CROSSING THE CONTINENTAL DIVIDE ON THE ROLLINS PASS BRANCH, DENVER, NORTHWESTERN & PACIFIC RY.

(This photograph is absolutely unique, as no such condition exists, or is such a photograph possible, on any other line that we know of on the American continents. The photographer caught the train in the two minutes it occupied in passing the crest, and not many days later the pass was snow-shedded, so that it can never be taken again. The elevation of the train as depicted is 11,390 ft. above tide-water. The vertical distance between the first track shown in the photograph and the train on the summit is 650 ft. The horizontal distance to the second track is 825 ft., and to the summit 1,800 ft., and the train traverses a distance of four miles from the first track to arrive at the point where it shows on the sky-line. The lake shown in the foreground is known as "Yankee Doodle Lake." This photograph is published by permission of Mr. W. Weston, Mining Engineer in charge of the Industrial, Land and Mineral Department of the Denver, Northwestern & Pacific Ry., who has copyrighted it, and it is the first and only publication of it that has been permitted.)

FIG. 5. CURVE AROUND YANKEE DOODLE LAKE, ON ROLLINS PASS BRANCH.

on both sides. The height of ridges over tunnels varies from 60 ft. in the lowest, to 600 ft. in the highest.

The material was to a large extent solid rock, and capable of standing, but owing to the numerous seams in the granite, which indicated that the climatic changes would tend to loosen up the material to a certain extent, it was thought necessary to insert a timber lining wherever any doubt existed as to the permanency of the rock. In these cases, the section was excavated large enough so that the timber could be placed and the requisite size preserved. In nearly all cases 12x12 in. timbers were used for posts, wall plates and the 5-segment arch. In tunnel 16, owing to the decomposed nature of the granite, which was saturated with water, 8 x 20-in. timbers were inserted both for posts and arch-segments, placing them side by side (with only one inch between); without any wall plates, and with a spreader timber in the bottom framed against the mud still, at an average distance of 8 ft. apart. This kind of construction was used for 100 ft., and for the balance of the tunnel the ordinary 12x12 in. timbers were used.

Very little water was found in any of the tunnels, and in No. 16, after the work was completed, the prevalence of water was not noticed to so great extent as during the construction.

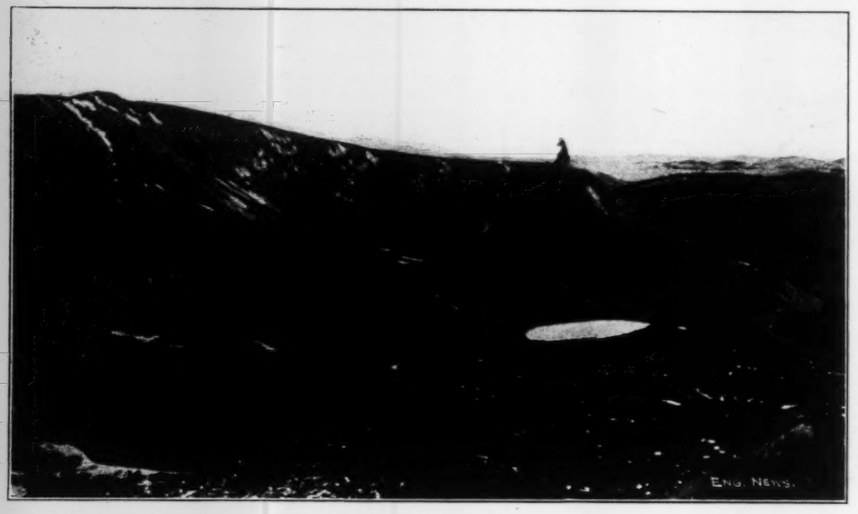


FIG. 6. VIEW OF TUNNEL 33 AND APPROACH FROM THE CONTINENTAL DIVIDE.

BRIDGES.—The main line has a very small number of bridges and trestles, considering the character of the country. All are of steel plate girder construction, on masonry abutments. Two of the structures are unimportant bridges, in the plains section, crossing irrigation canals. That across Coal Creek consists of three 64 ft. and two 32 ft. spans, and the track is 63 ft. above the creek bed. The upper crossing of South Boulder Creek, now a timber trestle 112 ft. long, will be replaced by steel. Besides these are 45 temporary timber trestles on the main line east of the junction with the Rollins Pass Branch, which are being filled in. These vary in length from 1 panel of 16 ft. up to 23 panels. In the mountains it was impracticable to make the permanent fills during construction, without expensive borrow, and as the track was needed to allow of bringing the material by construction train from a distance, trestles were built, which will be filled with a steam shovel and work trains.

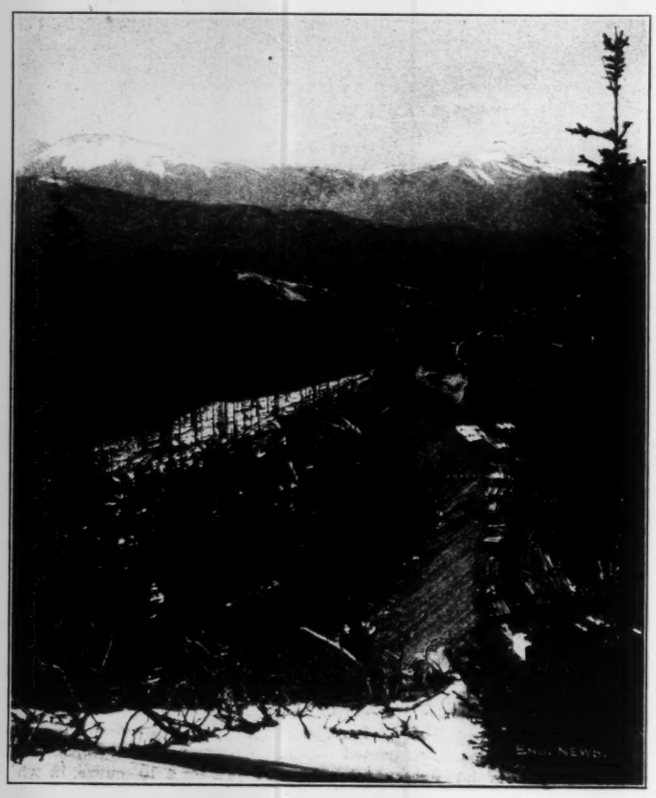


FIG. 7. LOOP SIDING, ROLLINS PASS BRANCH, LOOKING WEST FROM THE CONTINENTAL DIVIDE.

The trestles are very strongly built. Each bent consists of six 12 × 12 in. posts. The standard height is 20 ft., but where more than one deck, the top one is only 16 ft. The lateral bracing is of 4 × 10 in. The panel length is 16 ft. Eight stringers of 8 × 20 in., in lengths of 32 ft., made up into two chords, carry the track. No jack stringers are used. The cap of the bent is 12 × 16 ins., but sills are only 12 × 12 in. Besides guard stringers, 80-lb. steel guard rails are laid, which extend 60 ft. beyond ends of the bridge, laid 10 ins. inside of the track rails and connecting at a point in center of track at the ends. The ties are 8 x 8 ins. x 10 ft., laid 12 ins. c. to c. The longitudinal girts are 6 ins. x 8 ins. The material used is all Oregon fir. The bents have pile foundations throughout. No masonry foundations are used. Between the ties is a filler 2 × 4 ins. set on a block, which makes a floor across the bridge, and on this is placed a 3-in. layer of slag for fire prevention.

The highest trestle is that across Bull Gulch, near M. P. 25. It is 81 ft. at the highest point.

For designing permanent bridges, the basis of calculation was Class E-52 Cooper's Specifications for Railroad Bridges.

ROLLINS PASS BRANCH.—This is the present constructed line over the summit of the Continental Divide. It was constructed so that Middle Park and the country beyond could be reached without waiting for the construction of the tunnel through the main range. Rollins Pass is a saddle in the divide about 6 miles north of James Peak, and 3 or 4 miles north of the projected main range tunnel, and it is near the head of a fork of Middle Boulder Creek. The Rollins Pass Branch leaves the permanent line at a point from which a 4% equated grade, with necessary easements for sidings, would reach the elevation of Rollins Pass, this point being 4.9 miles easterly from the east portal of the main range tunnel. The length of this branch is 23.5 miles. The west end, near Arrowhead, is 5.1 miles beyond the west portal of the main range tunnel, by the present located main line. The branch leaves the permanent line at M. P. 53.3, and rejoins it at M. P. 66, thus making 10.8 miles more distance than via the main line.

The East junction is at elevation 9,482, and the summit 11,660 ft., there being a rise of 2,178 ft. in the 12 miles. The descent on the west slope is 2,150 ft., in a distance of 11.5 miles. The maximum grade is 4%, compensated .035 per degree on curves. Though the grade is usually kept up to the maximum on the east slope, there is some grade of only 3.5%, and about 2,000 ft. of level track. On the west slope, the grade is about all 4%, except for about 2,000 ft. of 1.5%. For the 3,000 ft. across the summit, the grade is practically level. 16° was adopted as the maximum

Fig. 8. Loop Over Tunnel on Rollins Pass Branch West of Continental Divide.

curvature on this line, but the topography of the country is such that their use is only resorted to in few instances. All curves of 2° and over are spiraled. For the 16° curves, the shortest spiral used is 90 ft. There is one 16° curve of 241°, and one of 193°.

There is one tunnel of 170 ft. on the east slope, and one of 490 ft. (No. 34) on the west side. The track is elevated for a speed of 20 miles per hour for passenger trains. The roadbed is 16 ft. wide in cuts and 14 ft. in fills. 5,675 ft. of the line has been snow-shedded. The experience of this winter (1904-05) will afford a good test of the matter of location of snow-sheds, but it is presumed that the present construction is ample.

The track construction is precisely the same as used on the main line, including the use of 80-lb. rails, with 3,360 Texas long leaf pine ties per

mile. Construction of both the main line and Rollins Pass Branch was carried forward far in advance of track-laying, so that practically no assistance for delivery by train of contractors' supplies and material was furnished.

The branch is a very interesting piece of engineering work, and the scenic features quite attractive. The altitude attained (11,660 ft.) is greater than that of any other North American standard gage railway. While the Rollins Pass Branch is sometimes referred to as the "temporary line," it is in no sense inferior in construction to the main line, and is "temporary" only as a means of carrying traffic to the region of Middle Park and Westward, until such time as the main range tunnel is completed, and the main line extended.

PROJECTED LINE BEYOND PRESENT TERMINUS.—Construction is at present progressing on the permanent line from Arrowhead, through Middle Park, to Hot Sulphur Springs (Elevation 7,660), the county seat of Grand County. This beautiful park, or valley, in Grand County, Colo., is almost entirely enclosed by mountains. The Continental Divide slopes rapidly down into it from the east. At about 13 miles beyond Arrowhead the foot of the 2% grade is reached. The line now follows the park, striking Grand River near mile 90, and continuing down it to Hot Sulphur Springs at mile 100, and on to Kremmling at mile 117, main line mileage; elevation 7,320. This is at the head of Gore Canon, at the southwest corner of the park. After passing through Gore Canon, on a descending grade of 1% for about 4.4 miles, the line commences the ascent towards the low divide (Toponas Summit), separating Grand River from the Yampa River Valley, with an ascending grade of 1%. The Toponas summit, at elevation 8,298, is reached at mile 162. The line then descends into the valley, striking the Yampa, or Bear, River at about mile 172. The general route of this valley is followed nearly all the way to the Utah Line. A considerable detour to the north is made, and the line then runs westerly. There is a general descent, interrupted by two ascents required to get over local summits where it is necessary to keep back from the river to avoid canyons or broken country.

The elevation at Lily, at the junction of the Little Snake River, is 5,735. After making the second ascent, the line crosses into Utah at mile 347. It passes through the Vernal Valley, reaching an elevation as low as 4,700, and directly across the Uintah Indian Reservation, following up the Duchesne River and its tributaries to the summit of the Wahsatch Range at Daniel's Creek Pass. From here, at an elevation of 8,000 ft., the descent into the Provo River drainage begins. The descent to Charleston is nearly 2,600 ft. in 29 miles. The survey now follows down the Provo Canon to Provo Junction, and then turns northerly through the Utah and Salt Lake valleys by the same general route as existing roads. Salt Lake City is reached at 539 miles, the elevation being 4,225. By this route, after leaving the 2% grade at mile 77, the maximum grade in either direction is 1%, with long stretches of only 0.5%; but in ascending the east slope of the Wahsatch Range a maximum of 1.5% is required. In descending the Wahsatch Range to Charleston, moreover, there is a section of 26 miles with almost continuous 2% grade, on which 10° maximum curves are used. On to Salt Lake City the maximum grade is 1%.

Though intended primarily for the development of the country it traverses, this road should serve much better as a through line than either of the existing ones. The Denver & Rio Grande has no grades exceeding 1.42% in its ascent of the east slope of the Rockies, but there is a 3% grade descending Eagle River Canon on the west side. Over in Utah it has a long stretch of 2.4% grade ascending Soldier Summit, and the descent on the west side has nearly 7 miles of continuous 3.8% grade, compensated.

The Union Pacific, notwithstanding the splendid improvements made over most of its line in Wyoming several years ago, still has a stretch of several miles of 1.5% grade between Cheyenne and Buford, and also one of several miles of 1.75% grade in the Echo Canon in Utah, neither of which can well be bettered.

THE COUNTRY OPENED UP BY THE RAILWAY.—The territory to be developed, not reached by the existing railways, is approximately 300 miles east and west, by 100 to 180 miles north and south. It takes in all of Northwestern Colorado, including Grand, Routt and Rio Blanco counties, and in Northeastern Utah it contains the northern part of Uintah County and nearly all of Wahsatch County.

In the plains region near Denver are extensive coal fields, already largely developed; in the main range of mountains are large beds of building stone, as well as deposits of the precious metals; on the west slope of the divide, and also in many other localities further west, are fine forests of pine and spruce. At Hot Sulphur Springs and Steamboat Springs the road will connect with the outside world two very fine groups of mineral springs which should become popular, both as health and pleasure resorts. Through most of the country traversed by the valley of the Yampa or Bear River, and also that of the White River, are extensive deposits of coal, and the hauling out of coal is depended on as one of the chief factors in the new road's traffic. In Northeastern Utah are immense beds of hydro-carbon compounds, such as gilsonite and elaterite, the opening up of which will develop the region and also furnish much traffic.

Through all the valleys, from Middle Park to the Heber Valley, in Utah, there is much ground valuable for agriculture, while portions more elevated are well adapted for grazing. When the region traversed shall have become developed, there will be but few stretches along the line but what afford traffic, and the traversing of long distances through practically worthless desert land, such as is necessary on some of the through lines of railway, will not be required.

For the purpose of constructing the railway, a new company, The Colorado-Utah Construction Co., was organized. The management is practically the same as that of the railway company. Mr. Syl. T. Smith is President, and Mr. A. C. Ridgway, General Manager.

The contractors for the construction so far completed are Orman & Crook, of Denver; Geo. S. Good & Co., of Pennsylvania; and Streeter & Lusk, of Colorado.

The Chief Engineer of the Construction Company is Mr. H. A. Sumner, who has had many years of experience in the difficult work of location and construction of railways in the mountainous regions of the West. His chief assistants are: Mr. L. D. Blauvelt, Resident Engineer in charge of work east of the summit of the Continental Divide; Mr. E. A. Meredith, Resident Engineer for the work down the west slope of the summit; and Mr. H. A. Aulls, Office Engineer. Mr. Blauvelt had direct charge of the location and construction of all the work to the summit, including the east half of the temporary line. The work was divided into five-mile divisions, each in charge of a division engineer. In the difficult work in the mountains, each division engineer had two full parties, consisting of instrumentman, rodman, chainman, tunnel inspectors, etc.

It is an evidence of the intelligent policy of the company that most complete surveys were made and all possibilities investigated before starting construction, and also that no pains nor expense are spared in having all engineering work done in the most thorough manner possible.

SEWER VENTILATION AT WINNIPEG, MAN.

The prevalence of typhoid fever at Winnipeg during the past few months has given rise to much public alarm. In the public discussion on the causes of the outbreak, many condemned the city's sewer system and declared that the foul odors arising from the sewer inlets and ventilating manholes were causes of disease. In order to secure an expert opinion on this and other matters connected with the city's sanitary condition, water supply, etc., Mr. Allen Hazen of New York City was engaged to make an investigation and report to the city council.

Inasmuch as Winnipeg has a winter climate equalled in severity by fewer cities of its size in the world, some conditions arise in handling sewerage and water supply problems which are notably different from those generally prevailing. We print in full that part of Mr. Hazen's report, pertaining to the Winnipeg sewers, as it appears to us to be of particular interest:

In accordance with instructions received from Mayor Sharpe, I have examined the sewers, and the sources of the water supply of the city of Winnipeg, and beg to present the following report upon these matters, particularly as bearing upon the recent outbreak of typhoid fever, and the means to be taken to prevent a recurrence of it.

Your City Engineer, Col. H. N. Ruttan, has given me every facility for investigating the sewers, and all conditions relating to them. The sewers of Winnipeg are built on the combined system, that is to say, they remove both the house sewage and the rain water. They are capable of carrying about one-fourth an inch of run-off per hour from the area served. The original design of the sewer system was well considered, and it has been wisely and consistently carried out and extended. In the sewers now being built the best modern methods are being used.

Winnipeg is flat and not very high above the flood height of the rivers. There is some difficulty in designing sewers low enough at the extremities to sufficiently drain the adjoining ground, and at the same time with sufficient inclination to produce a fair velocity of flow, and to discharge into the river at an elevation high enough to prevent too much flooding and back water when the river is in flood. From the profiles of the main sewers which I have seen, I think the design is all that could be reasonably secured under the existing conditions in this respect.

The sewers are designed with inclinations to produce enough velocity to prevent the forming of deposits. The computations of the velocity are on the assumption that certain quantities of water flow in the sewers. As a matter of fact the actual flows are often less than the quantities assumed in making the design, and consequently the actual velocities are less than the assumed velocities, and the likelihood of deposits is increased. Usually this is a matter of little importance, because the rains occurring at intervals furnish quantities of water which flush out the sewers, and restore them to their original condition. In Winnipeg the conditions are different, in that for a very considerable proportion of each year, there are no rains, and even the winter thaws which melt the snow, thus furnishing water, are almost unknown. There is therefore a considerable period each year, when no natural flushing takes place, and flush tanks or other artificial means must be used to keep the sewers in good condition. In this respect the conditions are quite different from those in cities farther south.

VENTILATION OF SEWERS.

There are various ways of ventilating sewers. In nearly all cities the manhole covers are perforated to allow circulation of air. In many cities the catch-basins are made in such a way as to allow air to pass through them. In other words these are not trapped. In a considerable number of cities, including Montreal, Minneapolis, St. Paul, no traps are used upon the house drains, and in this case air is able to pass freely through such drains and through the soil pipes in the houses. Where this is done, the air in the sewer finds its way through the highest outlets, namely, through the soil pipes, and there is a down draft through the perforated manhole covers in the streets.

In Winnipeg all the inlets and all the house drains are trapped, and it is also necessary, on account of the cold climate, to put straw in the mouths of the sewers to prevent freezing, thereby shutting off this source of ventilation. The sewers are thus ventilated exclusively through the perforated covers of the manholes in the streets and in the absence of natural flushing, and with rather flat grades, which are unavoidable in a perfectly flat city, it is not surprising that odors are produced, and discharged from the manholes which at times are very disagreeable.

There is plenty of precedent for the use of traps. They are required in New York, Boston, Toronto and many if not most American cities. It is understood they are generally used in England but not in Germany. Colonel Ruttan has collected a large amount of information as to the use of traps in American cities. He has also an abstract of some of the most important reasons for using and for not using traps. He has also investigated the plumbing in a considerable number of houses in Winnipeg with the general result of finding that the plumbing is not associated with typhoid fever. In fact his statistics show a somewhat larger proportion of cases of typhoid fever in the houses where the plumbing is good, than in those where it is defective.

INFECTIOUS DISEASES NOT PROPAGATED BY SEWER GAS.

It was formerly thought that infectious diseases could be carried from one person to another, and from one house to another by the air of sewers. This idea was based upon conjecture rather than upon evidence. But as long as the matter was in doubt, the only safe course was to assume that disease might be so carried. The use of the trap thus seemed necessary.

But after many years of experience and long continued investigation there is not the slightest reason to believe that infectious diseases are carried by the air of sewers. The men employed to clean the sewers, and to care for sewage disposal works are free from this infection, even when the disease is prevalent in the houses entering the sewers. Disease is often carried by sewage, but not by the air of sewers.

Illuminating gas often enters sewers from the mains and gives rise to odors and other troubles, but this is an entirely different matter from the transfer of infection.

The belief is now firmly held that infectious diseases are not carried by the air of sewers, and, this being so, the chief reason for the use of the trap on house connections falls to the ground, and the reasons for not using it outweigh the reasons for using it.

It has been thought by many that the odors from the sewers in Winnipeg had to do with the typhoid fever. I agree fully with Prof. Jordan on this, and I wish to state most emphatically that the odors have had nothing whatever to do with the typhoid fever. Nevertheless they are disagreeable and should be done away with.

The most effective way of preventing odors from the manholes is to abolish the traps upon the house drains, or at least a part of them. I say a part of them, because a small proportion of the whole number of connections would serve to ventilate the sewers, and if the use of traps were made optional, instead of compulsory, as in St. Paul, it is probable that in a short time a sufficient number would be without traps to ventilate the sewers and do away with the present nuisance in the streets. It would not be necessary to require any one to do away with his trap who had a personal preference for it.

If the traps are done away with, there are two other matters which must be attended to, and which are both very important.

The first is: That the plumbing in each house in which the trap is omitted must be perfectly tight, and must be so kept. The inspection of plumbing should be frequent and thorough. It will be necessary to reorganize the plumbing inspection service to do this properly.

The second is: That means must be taken to prevent the soil pipes freezing above the roofs. In St. Paul it is found sufficient to enlarge the soil pipe at the top, so that a considerable amount of frost can accumulate in the enlarged end of it without obstructing the passage of air. In Minneapolis a galvanized iron jacket is required about the pipe above the roof, leaving an air space. This arrangement is, perhaps, better adapted to the climate of Winnipeg, but whatever means is adopted must be such as to insure at all times a free passage for the air.

If these precautions are followed, there is no sanitary objection to the removal of the traps.

Experience in the cities mentioned, and in many others indicates that it is possible to so control these conditions that no harm will follow the omission of the house traps.

I recommend that this course be followed in Winnipeg, that is, that the use of the house trap be made optional, but coupled with stringent regulations covering the conditions necessary to success without the trap. This will have the effect of removing the disagreeable smells from the middle of the streets. The foul smelling air will then escape above the tops of the houses where it will be unnoticed.

EXPERIMENTS ON REINFORCED CONCRETE PIPES MADE FOR THE U. S. RECLAMATION SERVICE.

By J. H. Quinton, M. Am. Soc. C. E.*

These experiments were made at Los Angeles, Cal., in the year 1904, by direction of Mr. F. H. Newell, M. Am. Soc. C. E., Chief Engineer of the U. S. Reclamation Service, and were supervised by the writer. The object was to determine if a more durable material than steel or wood could be used to carry water in pressure pipes across long depressions on canal lines.

FIG. 1. GENERAL VIEW OF REINFORCED CONCRETE PIPES.

(Pipe No. 4 under construction, has the framework, steel reinforcement and inside lagging in place.)

The surveys for the different projects of the Reclamation Service indicated that many such places would have to be crossed by both the main and secondary canals. The reclamation law provides that

when the payments required by the act are made for the major portion of the lands irrigated from the waters of any of the works herein provided for, then the management and operation of such irrigation works shall pass to the owners of the land irrigated thereby, to be maintained at their expense, etc.

As the payments referred to in this clause may extend over a period of ten or more years after the works are constructed, it was considered advisable to make all of the structures of material which would be lasting. It would be rather humiliating for the engineers of the Reclamation Service to be obliged to turn over to the settlers at the end of ten years' payments a structure which already needed renewal on account of the perishable material of which it was composed.

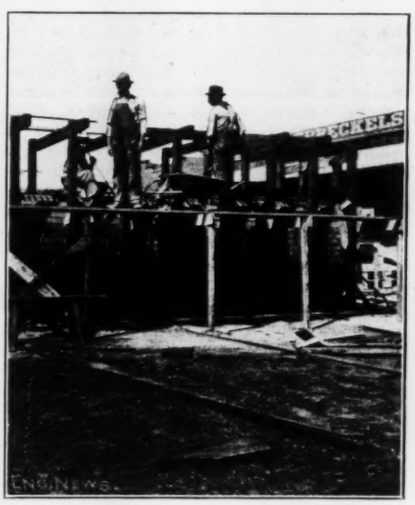


Fig. 2. Finishing Top of Pipe Without Inside Form.

Steel pipes are generally used as pressure pipes, but are naturally short-lived on account of the thinness of their shell. Asphalt coating adds considerably to the life of a steel pipe, but unless this coating is applied at just the right temperature, and the pipe handled with great care both in transit from the manufactory to the works and in laying, so that none of the coating is removed, it will not very materially add to the life of the pipe. A thin sheet of steel, even when coated, is soon attacked, in alkali soils, and very much weakened, if not rendered entirely unserviceable.

Wooden pipe, bound with steel rods, spaced in proportion to the pressure, is in many cases a great improvement over steel pipe. It has its drawbacks, however, as the steel rods are exposed to the same injurious action in alkali soils as the steel pipe. A wooden pipe suitably banded and surrounded by concrete would be an ideal pipe for warm climates where the pipe could be kept filled with water continuously; but in cold climates it would be dangerous to leave it full of water in the winter time on account of frost. It would then be subject to alternate wetness and dryness, which is not a good thing for wood. The great objection to having a wooden pipe dry out every year is the fact that the wooden staves of which it is composed shrink and allow the seams to open. When water is first turned into the pipe, the seams are liable to have grains of sand or small gravel deposited in them, and these prevent the even and true closing of the seam which is necessary for a water-tight pipe. If the pipe can be kept filled with water continually, this action does not take place, and the wood of the pipe is saturated with water so that it does not decay.

As the temperatures encountered in the reclamation districts vary from 30° below zero in the northern States to 120° in the shade in the southern States of the arid region, it is evident that the wooden pipe which might answer very well in Arizona would not be at all suitable for Montana.

All these matters being considered, it was decided to try if reinforced concrete could be used, and to what extent, for pressure pipes. Most of the projects in the reclamation districts require very large canals, and it was determined to experiment with a pipe of large diameter, which could be used to demonstrate the actual difficulties of construction, and to show just how such a pipe would act in practice. For this purpose eight large reinforced concrete pipes, each 5 ft. in diameter and 20 ft. long, were built and tested under water pressure, and their action carefully noted. This information will soon be published by the Reclamation Service, but meantime it may be of interest to the readers of Engineering News

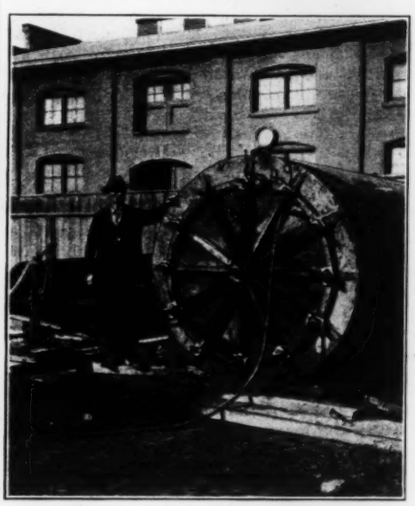


Fig. 3. A Completed Pipe Ready for Testing Under Hydraulic Pressure.

*Consulting Engineer, Reclamation Service, U. S. G. S., Washington, D. C.

to know the general precautions to be taken in making concrete steel pipe:

(1) Do not allow the sun's rays to touch the concrete when it is being mixed and placed in the form. If necessary build a shed over the work to insure this precaution.

(2) If the concrete steel pipe can not be made continuously by machine, do as much of the hand tamping as possible in radial directions. When the tamping must be done at right angles to the radius of the pipe, either in longitudinal or circumferential directions, avoid as far as possible the formation of seams or cleavage planes, from delays in placing the forms and adding fresh material. By making the concrete very wet, delays will not be so dangerous as in the case of dry concrete.

(3) Be careful in tamping not to spring the longitudinal rods, and use as few of these as will suffice to hold the circumferential rods in place, except in case of vertical curves in the pipe, when additional rods or steel cables must be used on the longer sides of the curved part of the pipe.

(4) Do not depend upon the tensile strength of the concrete, but make the steel rods of such size and distance apart as will insure no greater stretch of the steel than 0.04-in. in any rod from the maximum pressure to which the pipe is to be subjected.

(5) Make pipe 1½ ins. larger inside diameter than required, to allow of putting two coats of plaster on the inside.

(6) As soon as the pipe is completed, give the inside one coat of plaster ½-in. thick, composed of 1 of cement to 1½ of sand, and a small quantity of lime paste thoroughly cooled to retard setting. Keep pipe well wet ahead of the plastering. When this coat, which may be left rough, is dry, put on another coat about ¼-in. thick of plaster composed of 1 part of sand to 1 part of cement. This coat should be trowelled to a smooth surface, and when it is dry give the entire inside surface of the pipe a thick wash of fine cement and water.

(7) Provide for drainage of water which may leak through when the pipe is first filled, so that sufficient water may not remain in the trench to soften the ground under the pipe.

(8) Bury the pipe under ground so that there will be no place less than 2 ft. between the top of the pipe and the natural surface of the ground.

(9) In very cold climates provide means for draining the pipe so that it can be emptied at the end of each irrigating season.

(10) The soap and alum mixture may be used to advantage in the making of the concrete, but reliance for impermeability must be placed on the plastering rather than on the material of the pipe.

(11) Do not use concrete steel pipes for heads over 70 ft., except for short distances, where 100 ft. head might be allowed by taking special precautions.

The accompanying photographs show the apparatus employed for testing, and give a general idea of the size of the pipes and the scale on which the experiments were conducted.

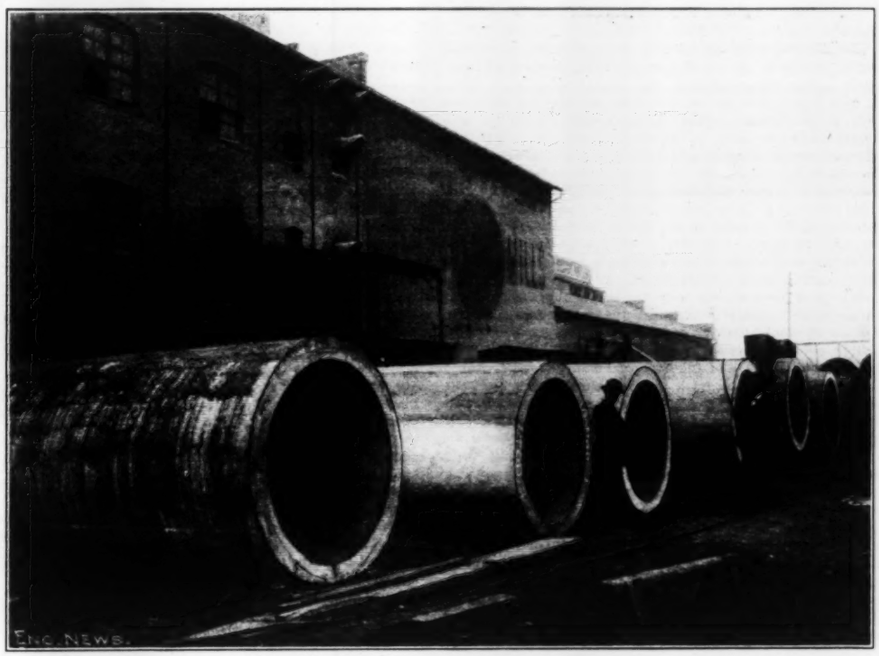


FIG. 4. VIEW OF COMPLETED PIPES.
(That in the foreground has been tested. Note the lime deposits in its exterior.)

Six of the pipes had reinforcement consisting of ¾-in. round rods, set 3⅜ ins. c. to c., and held in place by 8 longitudinal rods each ½-in. diameter and 20 ft. long.

The other two pipes had less reinforcement, and one of them was made in four lengths of joints, all of which will be explained more fully in the official published accounts of these experiments.

THE IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN ST. LOUIS AND CAIRO.*

By William P. Wooten.†

In 1872 the improvement of the Mississippi River, between the Missouri and Ohio Rivers, was begun in accordance with the provisions of the River and Harbor Bill for that year, which carried an appropriation of $100,000 for beginning the work.

The Mississippi River, above the mouth of the Missouri, is a comparatively clear stream flowing in a fairly stable bed. The Missouri, however, comes in heavily laden with sediment and the whole character of the Mississippi below their juncture changes. The bed and banks are chiefly of alluvial deposits, and as a rule, are easily eroded, causing constant changes in the position of the principal current and consequently a constant shifting of the whole bed of the stream.

The low water discharge at St. Louis, about 16 miles below the mouth of the Missouri, is about 30,000 cu. ft. per second, the ordinary flood discharge is about 750,000 and the maximum known discharge is about 1,200,000, the mean discharge being 225,000, of which the Missouri brings in somewhat over one-half.

The slope in the reach under consideration averages .44 of a foot per mile, but varies between one-half to double this amount. The river in its unimproved state varies from 0.5 to 1.5 miles in width and meanders from one side to the other in an unstable bed, between bluffs from three to eight miles apart, for a distance of about 160 miles. Thence it flows for a short distance through a gorge and emerges at Commerce, Missouri, into the alluvial alley of the lower Mississippi.

The variation in level at St. Louis ranges between limits about 35 ft. apart, ordinarily, but the highest known flood (in 1844) rose 42.5 ft. above extreme low water.

*A paper published by the Engineer School, U. S. A., Washington Barracks, D. C.
†First Lieutenant, Corps of Engineers, U. S. A.

The high water season is generally from March to July, low stages prevailing the remainder of the year. From Dec. 1 to March 1, navigation is usually suspended on account of ice.

Work upon this stretch of river was begun, as stated, in 1872, under the direction of Colonel J. H. Simpson, Corps of Engineers. For the first two or three years the work done was directed mainly toward the improvement of St. Louis harbor, several stone dikes constructed for the improvement of Horsetail Bar being the only work of importance, other than surveys done outside of this locality. A complete triangulation was made of the portion of the river between the Missouri and the Ohio, and in 1875 a project was prepared and approved for the improvement of this reach, to obtain a depth of 6 ft. above and 8 ft. below St. Louis, at low stages of the river. This project contemplated the improvement of the worst bars first, so as to afford the earliest possible relief to navigation, and the means proposed were contraction works, consisting of stone and brush dikes and training walls, supplemented by the revetment of caving banks. The work was to be done mainly by hired labor, only work whose character and extent could be definitely fixed beforehand being done by contract. This policy has been consistently followed throughout the whole work. The estimated cost of the work needed under this project was $3,159,200 for dikes and dams, and $4,000,000 for bank protection and maintenance.

In accordance with this project work was begun at several of the worst localities, the work being chiefly of three kinds; first, the revetment of such banks as were most in need of protection; second, the construction of low stone and brush dams to close chutes around islands and towheads; and, third, the construction of stone and brush dikes to effect contraction of the stream. Contraction dikes were constructed only at Horsetail and were connected by a longitudinal training wall. These works did not entirely accomplish what had been expected from them in the way of causing deposits, and, in 1879, pile and brush hurdles were placed between the dikes about 100 yards apart, to hasten deposits. The deposit of material was hastened by these hurdles so effectively that it was evident that stone cross dikes and dams might be dispensed with entirely and their construction was, in 1880-81, discontinued, hurdles being built in their stead.

The project of 1875 was modified in 1881, the principal difference being the change in policy as to the order in which improvements were to be made. It was determined to carry on the work continuously from St. Louis down stream, instead of first improving localities at which navigation was most obstructed. Changes in forms of construction were also introduced, hurdles being substituted for solid dikes and dams as above stated, and mattress being employed for protection of banks below low water in lieu of foot walls.

In accordance with this project work has been progressing from St. Louis and is now being carried on throughout the whole reach. The work now going on consists chiefly of bank protection and an extension of the contraction works in shoal portions of the river not yet brought to the adopted width of 2,500 ft. Pending the completion of the permanent improvement, the low water channel is to be improved each season by the use of dredges and other temporary expedients. The original estimate of the cost of the improvement, as revised in 1883, is $16,397,500. The total amount expended to June 30, 1901, was $9,485,219.34. The result of this expenditure has been the partial improvement of the whole reach between St. Louis and Cairo. During the last year the least channel depth was 6 ft., except for a few days when it fell to 5. The improvement is continuous for 60 miles below St. Louis, but is not complete at any point, and in the lower section work has been confined to the points which cause most trouble to navigation. It is believed that there can be no doubt of the ultimate success of the permanent improvement, and it is expected that with the present appliances for the temporary improvement of low water channels, a depth of at least 6 ft. can be maintained between St. Louis and Cairo until the projected depth of 8 ft. is obtained through the extension and completion of the permanent works.

In order to properly appreciate the principles which should govern any attempt to improve an alluvial stream by regulation, it is necessary to have some idea of the natural causes which operate to produce the conditions found in the beds of such rivers.

A stream flowing through soil which is capable of erosion by water flowing at the velocity found in the stream will not follow a straight course; irregularities in the bed, by deflecting the current to one side, cause a greater local erosion of one bank than of the other and a slight curve is formed. The current passing nearer the concave bank, this curvature is increased by further erosion and at the same time the current being deflected by the curve to the opposite bank cuts out a reverse curve below. Thus the river finally makes for its bed a series of bends which go on increasing in curvature until the river bed is lengthened sufficiently to reduce the slope below that value which, taken in connection with the cross section of the river, will cause its bed to be eroded, and the latter will then become stable.

This condition of equilibrium might be quickly obtained

by a river constant in its discharge or varying through small limits, but in the case of a great river, with variations in its discharge, such as are found in the Mississippi, it is evident that a position which gives a condition of equilibrium for one stage is not at all the same as that for some other higher or lower stage. Were it possible to fix and hold for the river a cross section such that every stage of the river should have its proper normal profile width as defined by Schlichting, then the ideal would be reached; but it is hardly necessary to point out the impossibility of effecting such a condition in the case of the Mississippi. The most that can be done, and the most that it is really necessary to do, is to construct such works as will hold the river during its lower stages in the bed which it has made for itself and prevent it, during its high stages, from cutting a new channel and entirely forsaking the old.

Simultaneously with the changes in the banks of the river due to erosion or deposit we find similar change in the river bottom, pools being dug out of greater or less length, separated by bars formed of the sediment deposited by the river.

These bars and pools are formed by the river chiefly during its high stages, while the action of the water as it falls, tends to reduce the differences in the level of the river bottom. This is quite forcibly illustrated by the fact that soundings on the Horsetail Bar below St. Louis, during high water in 1877, showed that the bottom of the river had been raised to a height of 10 ft. above low water. The bars are formed wherever, owing to an increased high water cross section normal to the current, the velocity of flow is checked, causing a deposit of sediment. Pools are formed where the opposite conditions prevail. Deeper water is, as a rule, found in the curved portions of the bed along the concave bank, the reason being that the shape of the curve throws the current into the concave bank and the contracted current sets up an erosion which is intensified by eddy currents. In straight reaches, on the other hand, and in crossings from a pool near one bank to one near the other, the bars are found, due to the fact that the current, which was in the former case found along one bank, now spreads more or less uniformly over a much greater section, with a correspondingly reduced velocity.

The origin of bars thus formed is the material rolled along the bottom by the stream, that part which is carried in suspension playing a much less important part. It is therefore chiefly local in origin, the material forming any one bar having been recently removed from the bottom or the banks not far above.

To obtain and maintain a good navigable channel the following requirements are given by General Simpson (Annual Report of Chief of Engineers, 1875, part 2, page 485):

1st Sufficient depth at all stages.
2d A judicious location.
3d Stability in position.
4th Facility of approach to landings.
5th Easy changes of direction.
6th Moderate velocity of current.

There have been many advocates of confining attention to the amelioration of the low water channel as it appears each year. This would be done by opening a channel by dredges, portable jetties, or otherwise through each reef as it appears, trusting to the current to maintain it until next high water. This might be possible were the reefs always fixed in position, but the continual shifting of the reefs makes it almost certain that the channel will be quickly filled and consequently it would be necessary to open it a number of times each season. In striving to secure a given depth in a stream we must work towards it through one or more of its correlated elements, width, volume and velocity. The volume of discharge is of course not subject to our control and must be accepted as found. For a given width a reduction in velocity would necessitate an increase in depth. Such a reduction would also be desirable as diminishing the sediment bearing powers of the stream. But the velocity is a function of the slope and the hydraulic radius, and as an increase in depth involves an increase in the hydraulic radius, it follows that the velocity can only be reduced by reducing the slope. A reduction of the slope can be obtained by lowering the water level at the upper end of the reach or by increasing the length of the reach. A reduction of slope, by lowering the level of the upper end, is always a consequence rather than a cause of river improvement and is to be avoided as much as possible, as it necessitates a reduction in the depths above the improved portion. One result of the improvements under consideration in this paper has been the lowering of the low water level at St. Louis. Exactly how much this lowering has been, cannot be determined from the insufficient data available, but it is believed to be about 2.5 ft. The lengthening of the river as a means of reducing the slope, can, of course, be effected only to a very small degree and is touched upon chiefly to show the undesirability of shortening the stream in any way and to furnish an additional reason for preserving easy curves and avoiding cut-offs.

This leaves us then the element of width as the only one within the range of control by modifications of which the river may be induced to cut itself a deep channel. Contraction of excessive widths is then the easiest and most practicable method of securing the desired depths.

The second requirement, the judicious location of the improved channel, is best secured by following the natural tendencies of the river and endeavoring to hold the river in the course which it has worked out for itself rather than by attempting to force any violent change in its course. It is a well known fact that any great and sudden change made in the channel of a stream upsets its regimen for a long stretch above, and a considerable time must elapse before a condition of equilibrium is resumed. It is stated that the Mississippi River, above Kaskaskia, has not yet entirely accommodated itself to the conditions brought about by the Kaskaskia cut-off by which the channel was shortened five or six miles in 1881.

The objections to straightening the channel, a method which formerly had its advocates, have been stated already. The suggestion that the channel should be made to follow the bluff has in its favor only the fact that one side of the stream would be hard and unyielding and would therefore need no protection. To offset this advantage which is more apparent than real, we have the fact that as the bluffs are approximately straight this proposition meets with the same objections as the one just mentioned. Any considerable changes made in the location of the channel would also greatly disturb existing business relations. The advisability of following existing channels is thus in accordance with policy as well as with engineering considerations.

The third requirement, stability in position, is essential to the establishment of facilities for trade. The necessity for the channel following a fixed line needs no demonstration. But this stability in position must be taken to refer not only to the axis of the current but also to the bars.

The position of the bars in the natural river are constantly changing. The sand proceeds slowly down stream in waves. If, as the result of works of improvement, these reefs or bars can be made to remain in definite localities, if the bars can be fixed in position, then their improvement either by permanent works or dredging is a much easier problem and can be undertaken with the assurance that your bar will not elude your improvement work by moving down stream.

The fourth requirement, facility of approach to established landings, should really be considered as a part of the second requirement, i. e., the judicious location of the channel. This requirement is often in conflict with an easy solution of the problem from an engineering point of view, but it is a requirement of considerable importance and must be given its full weight in deciding between different lines of improvement works for a given locality.

The fifth requirement, that changes of direction should be easy, is in the interest not only of stability, but also of easy navigation. However, these changes of direction should not be too easy. A channel maintains its depth best along a curve, but if the curve is too flat the channel will not follow the concave bank throughout and the difficulties met with in the straight reaches are encountered. If, on the other hand, the curve be too sharp, erosion of the concave bank is greater, bank protection is more costly and navigation more difficult.

The proper radius of curvature differs for different streams and must be separately determined for any given one. Thus a radius of from 5,000 to 10,000 yards might be proper for the Mississippi, while such a radius would be entirely too great for a smaller stream.

The sixth and last requirement, that the velocity shall be moderate, does not, in the case of the Mississippi, call for any work especially designed to meet it. If the contraction works are kept to their proper dimensions the velocity will not be so excessive as to impede navigation.

The methods which have been followed on the Mississippi River between St. Louis and Cairo for meeting these requirements have been mainly contraction works and bank protection. The object of contraction works is to so reduce the width of the river as to force it to scour out for itself a deeper channel in order to secure a cross section sufficient to carry its volume of discharge. The width to which the river was to be contracted was fixed at about 2,500 ft. Dikes or dams closing side chutes around islands or towheads are included under the head of contraction works as both their purpose and their result are to contract the waterway.

The bank protection was intended, of course, to protect the banks against erosion, there being two reasons why the erosion of the banks should be prevented: first, in order to hold the channel in a fixed position by preserving the bank itself; and, second, in order to cut off as much as possible the supply of bar forming material.

The chief question to be decided in each locality in which contraction works are put concerns the line which the channel must be made to follow. In studying the works already placed in the portion of the river under consideration, we find instances of both the right way and the wrong way to place them. As is well known, whenever a river flows around a curve the channel is always in a fixed position, and we find that wherever contraction works have been placed on the convex bank, and bank protection on the concave, good results have invariably followed. Other considerations, more practical and less theoretical, but equally important, support the same method, i. e., the considerations of ease of construction and of cost. The convex side of the river, being less deep than the concave and having a less velocity of current, contraction works are more easily constructed and more efficient in causing deposits than when placed on the concave side.

In straight reaches in need of contraction the works should, if practicable, be so placed as to change the reach from a straight one to one having a succession of curves. When this has been done the results are as good as in the former case. But where the works are so placed as to flatten out curves, converting them into almost straight reaches, or where straight reaches already in existence are preserved, the result has been a channel which is constantly shifting in position and frequently insufficient in depth.

Another very important result of the river's following a series of curves instead of a straight reach is the permanence secured in the position of the bars. As bars will occur only at the crossings, their position is definitely known and if the works are properly designed they will rarely interfere with the projected depth, and at such times as they do give trouble a little dredging will give prompt and sure relief.

It follows then that the requirement of sufficient depth at all stages, as well as that of stability of position, is best fulfilled by placing the contraction works so as to guide the channel as far as possible into a series of easy curves. Incidentally this also slightly increases the length which has been mentioned as a desirable end to be attained.

The use of ground sills has found no place in the scheme of improvement followed thus far. The action of the ground sills is to ultimately raise the level of the bottom in the pools and thus increase the slope in these places. As an increase of slope in one place necessitates diminution in another, the final result is to make the slope more uniform. During the formation of the deposits necessary to raise the river bottom the sills act as submerged dams and effect the same results. This system has been followed successfully with many European rivers, especially with the Rhone, where the drop of over 4 ft. in the low water level at La Mulatiere, due to previous improvements below has been in a measure regained. The use of such a system seems hardly necessary with the Mississippi as the slope is not very excessive and the results obtained from contraction of the width and protection of the banks justify the expectations that the projected depth can be obtained by these means alone. Moreover, the use of ground sills would involve great expense on account of the width of the river and the great depths of water in which they would have to be placed. Works of this nature in the reach under consideration being founded on an unstable bottom would also be quite vulnerable to attack by the violent floods which occur, as is seen from the damages caused to the stone dikes and dams at first constructed.

In beginning the work of improvement of the river, General Simpson determined upon the amelioration of the worst bars first and made his estimate apparently on the supposition that the removal of the bars then in existence would bring about the projected depth at once. He evidently underestimated the effect which would be produced by the improvement of one locality on the river above and below. Bars act as submerged dams separating pools of slight slope, and the lowering of one of these dams lowers the water in the preceding pool, increases the slope at the preceding bar and aggravates such bad conditions as may be found there already, or, in many cases, produces bad bars where the depth had previously been sufficient.

Bars lower down the river are also built up by the deposit of material scoured from the bar under improvement. Thus the improvement of one bar forces an extension of the works in both directions and to a degree which can hardly have been foreseen. Sufficient allowance for this was not made in the original estimate, and later, in 1883, the estimate was more than doubled.

In the project of 1881 the order in which the work was to be done was changed and it was decided to proceed with the work uniformly down the river from St. Louis. From an engineering point of view the question as to whether the original improvement should have proceeded from St. Louis down the river or from Cairo up, is an open one, but at this time practical considerations due to the fact that most of the work which had been done was in the vicinity of St. Louis were undoubtedly sufficient to justify the order of work adopted.

TYPES OF CONSTRUCTION.

The contraction works first used in 1874 consisted of spur dikes, each dike being a riprap of stone built 8 ft. above low water and superposed on a foundation or platform of brush from 2 ft. to 5 ft. in thickness and varying in width to suit the height of the dike, held in place by piles until loaded, an apron of brush about 2 ft. thick also held in position by piles and stone having been previously laid below and alongside the dike, though not connected with it, to prevent the dike from being undermined by the fall of water over it. The dikes were 3 ft. wide at the top and the stone took its natural slope. Where such a dike was constructed on an alluvial bank it was carried back 200 ft. over the bank. The bank was further protected by a longitudinal dike 250 ft. long, with cross dikes 100 ft. long, running back on the shore at its ends.

Dams closing sloughs were similar in construction. The

design was modified, in some instances, by constructing the dike of alternate layers of brush and stone instead of a mound of stone on one layer of brush and with this and other slight modifications was continued in use until about 1881.

It was intended to connect the channel ends of the cross dikes by a training wall as soon as deposits were made, and one was built at Horsetail Bar but was never fully completed.

Stone dikes thus constructed were found not to be so efficient in causing deposits as had been desired and expected; so, in 1879, a number of hurdles were interpolated between them to hasten the deposit of sediment. The results obtained were very satisfactory and, in 1881, the old dikes having proved costly to build and difficult to maintain and not being very efficient it was determined to rely entirely upon hurdles, and contraction works undertaken since then have been hurdles alone.

The hurdles built in 1879 consisted of a row of light piles about 5 ft. apart, connected together by weaving or wattling willow poles between them and pushing willow brush vertically into the interstices of the wattling. The top of this brush projected about 8 ft. above low water while the lower courses of the wattling could not be forced down lower than 8 ft. below low water. The cost was about 80 cts. per lineal foot. These hurdles were frail in design and were not expected to last more than one season. Where the water was too deep to drive these piles and construct the hurdles in position a curtain of woven willow poles and brush was constructed. The lower edge of this curtain was then anchored either to a horizontal mattress or directly to the bottom and the upper edge supported by buoys. Longitudinal walls built of hurdles were known as primary, and cross dykes as secondary hurdles. As the use of hurdles was continued the designs were modified and improved, and changes were made which rendered them stronger and more permanent, the present hurdle being finally evolved. The present hurdle consists of a row or parallel rows of three-pile clumps spaced 8 to 12 ft. apart, the piles in each clump being drawn together and fastened at the top by a wire cable. Where the water is shoal and the current weak a single row of clumps is usually sufficient; under other circumstances the clumps are staggered in such a way that longitudinal stringers can be placed between the rows to transmit and distribute strains. One pile in each clump in the upstream row reaches the level of the 25 ft. stage, the other piles in the first and second rows being 5 ft. lower, while the remaining rows are 5 ft. lower still.

The foundation mattress varies in width from 75 to 100 ft., about 35 ft. forming an apron on the upstream side. Extra stone is always thrown around the feet of the piles to prevent scour where the mattress is broken by driving the pile through it.

The channel ends of the hurdle are protected by T heads of two rows of clumps projecting 50 ft. above and 100 ft. below the hurdle, the foundation being a mattress 120 ft. by 300 ft. Buttresses of stone are placed at the channel ends, and the shore ends are protected by revetments for about 300 ft.; drift collected above the hurdles is sunk by laying on top of it a sort of mattress of brush as evenly and rapidly as possible and then weighing the whole with stone. A curtain of brush is constructed and supported by the piling where no drift occurs. As soon as the hurdles caused a deposit reaching about the 17 ft. stage, willows began to grow and by checking the velocity of high water caused further deposits to be made. The artificial banks thus formed may be protected as described for natural banks. The distances apart of these hurdles is from 1,000 to 1,500 ft. Their cost ranges from $10 to $35 per lineal foot.

The original plan adopted for bank protection was to excavate, where necessary, a trench to the depth of 8 ft below lowest water, and fill it with brush in crossed courses, the tops reaching outward as far as practicable to form a mattress to protect the base from scour. On the brush, riprap is placed until it appears at mean low water, assumed 5 ft. 6 ins. above lowest low water where it formed the base of the stone revetted slope, with an inclination of 1 vertical to 2 horizontal. This work has served its purpose well and is still in good condition, probably owing its stability to the fact that it was placed in comparatively shallow water. From 1875 to 1881, protection under water, or subaqueous protection, was given by rafts or mattresses of brush from 40 to 70 ft. wide. These mattresses were effective except in deep water with strong current where their outstream edge was undermined.

In 1881 was adopted the form which, with modifications as to details, has remained in use until recently. It consists of a woven mattress of cottonwood, or preferably, willow brush. It has but one thickness of brush woven upon poles, is thin and flexible and sufficient strength during construction is secured by ample fastenings of nails, spikes, wire and cable, all of iron. Their width must be sufficient to reach to the foot of the eroding slope and a standard width of 120 ft. is adopted as ordinarily sufficient. They are, as a rule, made continuous for each locality, lengths of from 5,000 to 10,000 ft. having been made and sunk. They are sunk and held in place by stone, and furnish permanent protection to underwater slopes, the few known failures having been due to the undercutting of the water which subsequently deepened. The average cost of brush mattresses 125 ft. wide is $6 per lineal foot.

During the past four years a number of lumber mattresses have been built. The lumber used is the commonest culls, 4 to 6 ins. wide, 1 in. thick, and not less than 12 ft. long. The mattress is formed by weaving the plank over and under plank laid longitudinally about 3 ft. 9 ins. between centers, like large split basket work. These mattresses require much less bulk of timber and of stone than the brush mattresses, can be built about twice as fast and cost only about $3.75 per lineal foot. Their only disadvantage so far as known consists in their breaking up worse when piles are driven through them.

Protection above water is given by grading the bank to its natural slope and covering with riprap. The paving is usually done as far as the river had graded its own bank and resumed the following season after the high water has extended the grade further up the bank. When necessary to grade the bank by artificial means it is done by the hydraulic method or by means of shovels, etc.

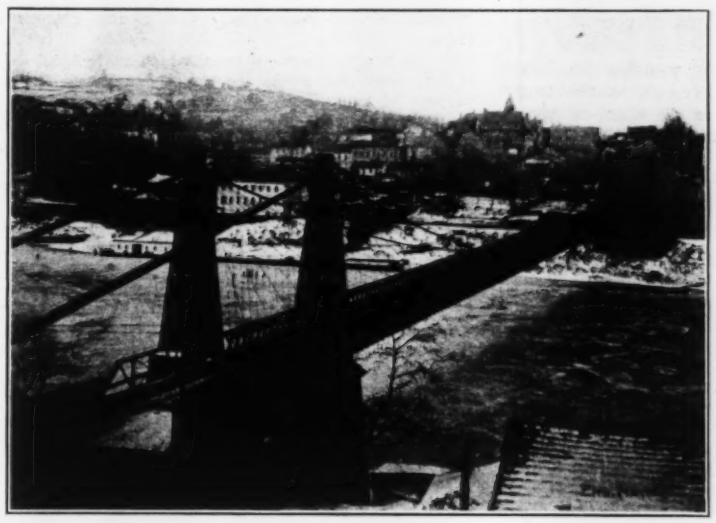
In addition to the permanent works of improvement, each year a certain amount of work is done to afford temporary relief to navigation or to hasten the results of the regulation works. The devices employed for this purpose include dredging and the use of temporary petties to produce scour. The plant includes three suction dredges, a jet dredge, a tow and dredge boat, two other tow boats arranged to use their wheels in washing channels through bars and panels for about 10,000 ft. of portable jetty. Several types of portable jetties or temporary dykes have been used. The type most favored is constructed by driving a row of piles along the line selected and connecting them by a stringer which serves as a support for the upper ends of corrugated sheet steel panels, whose lower end rests on the bottom of the river.

Each panel is 10 ft. wide and from 10 to 20 ft. long, depending on the depth where it is to be used. To prevent scour taking place under the panels, a small fascine mattress 8 to 10 ft. wide is fastened to the lower edge of the panel and sunk with riprap. At the end of the low water season the panels and piles are taken up and preserved for future work.

THE MONONGAHELA RIVER SUSPENSION BRIDGE AT MORGANTOWN, W. VA.

By W. H. Boughton.*

Much interest has developed in the suspension bridge at Charleston, W. Va., which failed recently. A description of the bridge and of the cause and manner of failure was published in Engineering News of Jan. 5, 1905. It would be well if interest in such structures could be more thoroughly aroused before they fail.



SUSPENSION BRIDGE AT MORGANTOWN, W. VA., BUILT ABOUT 1855.

The bridge across the Monongahela River, at Morgantown, W. Va., is similar to the Charleston bridge in many respects, though 25% longer and pretending to better design. Like the Charleston bridge before failure, this bridge is not generally regarded as entirely safe; indeed, one cable did break about ten years ago, as at Charleston, under a heavy load of snow, but, fortunately, the other cables held till repairs could be made, so that the failure was not complete. The bridge was built fifty years ago by a private company, and operated as a toll bridge till several years ago.

The span, center to center, of towers is 608 ft., and the roadway is 20 ft. in clear width, with a 3-ft. walk elevated 6 ins. running along the center of the roadway. The roadway is on a grade, it being 11 ft. higher at the east towers than at the west. The masonry towers are 42 ft. high above the roadway. At the center of the span the floor is 25 ft. above low water in the pool above dam No. 9, but the bridge is never endangered by high water. Forming part of each approach, there is a short truss span, having no connection with the cables. The east span is over the Baltimore & Ohio R. R., and the truss and cables are exposed to the action of locomotive gases. The anchorages are about 150 ft. from the towers.

The floor on the suspension bridge consists of a single layer of 3-in. planks laid diagonally on eight lines of 4 in. × 4 in. stringers resting on the floor beams. The floor beams are spaced 4 ft. apart, and each is suspended from the cables by a ¾-in. diameter rod at each end. Each floor beam consists of two pieces 2½ × 12 ins. The connection of suspenders to floor beams and cables is similar to that on the Charleston bridge, but modified as required for three cables instead of two. Auxiliary support for the floor is provided out to the quarter points of the span. Ten wire rope stays run from the top of each tower to the floor connecting to every fourth or sometimes fifth beam. They are lashed to the suspenders where they cross them. At the tower eight of the stays connect by clevises to three lines of 1½-in. wire rope, which, together with the other two stays, run independently to and into the anchorage. These ten stays cannot be very efficient. As the live load comes on they appear to come into action somewhat, but in an uncertain and unequal manner. There is no satisfactory provision for taking up the horizontal force induced at the feet of the stays. Compression blocks are inserted between the floor beams, but the end blocks do not connect well with the towers, and some are badly decayed and some are absent entirely. The design of the floor itself is not suitable to make good this deficiency.

There are three cables on each side of the roadway made of parallel wires bound at intervals only. The cross section is between a rectangle and an ellipse, but if reduced to an equivalent circle would be about 3¼ ins. in diameter. Just before crossing the tower each cable divides into two smaller ones. Each of the latter connects about 15 ft. from the anchorage with a 2¾-in. round bar by means of a clevis and pin. A turnbuckle provides from 15 to 18 ins. adjustment in each of the six anchor bars. At the time when one cable broke in or near the anchorage, all the cables were cut off at both ends of the bridge, and these anchor bars were put in. The detail within the anchorage cannot be determined, but it is seen that the main wire cables do not now enter the masonry. The sectional area of the bars is over 80% in excess of that of the wire in the cables. The difference in strength is probably less, though this is disputed; but a failure by rusting off within the anchorage, as at Charleston, does not appear likely to occur.

The bridge has stiffening trusses about 5 ft. deep center to center of chords, continuous from tower to tower, and anchored down at both ends. The members of the trusses are timber except the verticals, which are each a 1-in. round rod running down and attaching to a floor beam. The panel length is 4 ft., corresponding to the spacing of floor beams. The top chord consists of two side pieces 2½ × 7 ins., and one cover 2½ × 12 ins. The bottom chord is one piece 4 × 8 ins. These stiffening trusses are such only in name. They are wholly incapable of serving such a purpose.

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The splices are worthless for transmitting stress. The top chord has opened at most of the splices from ¼ in. to 1½ ins. In some places shims have been inserted at some time, and now adhere to one side of the joint, but leaving still a gap of over an inch. In many panels the bottom chord has rotted through. The separate pieces composing it meet on top of the floor beams at panel points without any pretence of a splice. Instead of each chord being adapted to take both tension and compression, neither one is capable of taking much of either kind of stress. The diagonals do not act promptly, if at all, when a live load comes on the bridge. A panel in which both diagonals are tightly in place is the exception, and as many as seven consecutive panels have been found in which both diagonals were loose. It is not surprising that a wave can be seen to move along the truss when a heavy load passes across the bridge.

The cables are cradled, and no other lateral bracing is provided.

When the bridge was under private ownership, the number of teams or number of cattle on the bridge at one time was limited; but now, as a free county bridge, the only restriction is one limiting speed. It is frequently subjected to improper loading, considering its condition, and it receives no systematic attention. A bridge of modern design is needed at this point to carry electric cars as well as the ordinary traffic. If this cannot be had, the present structure should receive very extensive repairs. The reader will probably not approve the plan of a local newspaper, which is to build a pier under the bridge at the center. A third bridge in the same class with the Charleston and Morgantown bridges and built about the same time is located at Fairmont, W. Va. It has been condemned recently, and will be replaced.

REPORT OF THE COMMISSION OF ENGINEERS ON THE RECTIFICATION OF THE SACRAMENTO AND SAN JOAQUIN RIVERS.

The most extensive work of river regulation now before the public in this country is the project for the reclamation and protection of the low-lying lands along the valleys of the Sacramento and lower San Joaquin Rivers in California. An area of nearly 1,700 sq. miles of very fertile land is now subject to overflow by floods in these rivers. To protect and reclaim this large tract, nearly twice as large as the State of Rhode Island, it is proposed to expend some twenty-three millions of dollars in works for river regulation.

The project had its inception in a State River Convention, held at San Francisco, May 23, 1904, at which a permanent organization, known as "The River Improvement and Drainage Association of California," was organized, and it was decided to appoint a commission of engineers to investigate river and flood conditions in the Sacramento and San Joaquin valleys and report plans for relief. Three of the Commission were to be eminent engineers residing outside the State of California.

As finally constituted the Commission was composed as follows: Major T. G. Dabney, Chief Engineer of the Yazoo Mississippi Delta Levee District; Major Henry B. Richardson, member of the United States Mississippi River Commission; Major H. M. Chittenden, U. S. A., in charge of the Yellowstone Park and the Missouri River; and M. A. Nurse, Chief Engineer to the Commissioner of Public Works for California.

The Commission was requested to make its report before Dec. 15, so that its recommendations might serve as a basis for legislation by the California legislature during the session beginning Jan. 2, 1905. This Commission, organized August 9, 1904, and immediately began a thorough study of the physical conditions of the rivers and valleys comprising the field of its labors. A vast amount of information and data was gathered, and the Commission then adjourned to meet in Sioux City the latter part of November, 1904, to compile data and prepare its plans and recommendations.

In brief, the plan, as submitted, provides for channel rectification and enlargement by joint action of natural and mechanical agencies, and the gradual concentration and confinement of the flood volume of the rivers and lesser streams of the Sacramento valley between lines of levees so located as to ultimately provide ample channel area for transporting all the flood volume. Until such channel rectification and enlargement shall have been secured through the joint agency of increasing current energy and mechanical excavation, relief will be afforded the levees by introduction of escapement weirs to temporary by-pass channels for conducting the surplus flood through the basins.

Inasmuch as the problem of River Regulation is one of growing importance in this country, and one on which very little authoritative literature exists, we have reprinted below sufficient extracts from the Commission's report to make clear the general nature of the problem and the methods proposed for its solution:

GENERAL STATEMENT OF THE PROBLEM.—In the Sacramento Valley and contiguous parts of the San Joaquin valley, there are some 1,250 sq. miles of very fertile land that is subject to overflow from every considerable flood in the Sacramento River, and about 1,700 sq. miles which are inundated by extraordinary floods. The problem presented for solution is to devise means for preventing the inundation of these lands by conveying the flood water that must pass through this territory harmlessly into Suisun Bay; and to correct the existing faults of the river channels with a view to avoiding the floods and promoting the interests of navigation.

REJECTED PROPOSITIONS.

Before proceeding to a discussion of the plans to be recommended by the Commission for the correction of the evils for which a remedy is sought, it may be well to clear the ground by eliminating certain propositions for the treatment of different features of the problem that have been strongly advocated heretofore by various authorities, and which, after due consideration, have been rejected by the Commission. These propositions are catalogued below, and are to be discussed in turn:

(a) The proposition which assumes the futility of undertaking to convey the flood water through the river channels, and provides an elaborate system of by-passes to control its flow outside of the rivers, as a permanent arrangement.

(b) The proposition to excavate a deep and capacious waterway through the Montezuma Ridge for the purpose of conveying the flood water from Yolo basin into the northern part of Suisun Bay, west of the Montezuma Hills.

(c) The proposition to excavate a high grade canal west of Yolo basin and across the Montezuma Ridge, for the purpose of intercepting the flow in Cache and Putah Creeks and other smaller streams, and conveyance of this water into the northern part of Suisun Bay, west of the Montezuma Hills.

(d) The proposition to divert Yuba, Bear and American Rivers into American basin.

(e) The proposition to divert the Sacramento River into the San Joaquin by a cut through Three-mile Slough or Sherman Island.

(f) The proposition to divert part of the flood water from Sacramento River into the San Joaquin by means of relief channels across Sherman and Brannan Islands.

Taking up these proposition in the order named above:

THE BY-PASS SYSTEM.—The by-pass scheme has been advocated by two engineers of recognized ability, Messrs. Marsden Manson and C. E. Grunsky. In their full and elaborate report of 1894, this plan has been worked out in detail and with great care and painstaking, and the meritorious character of the work done by them in this connection highly commends itself. Nevertheless, the Commission finds itself unable to accept this plan as a permanent solution of the Sacramento River problem, for the following reasons:

(a) The by-pass involves the maintenance, in a general way, of three rivers instead of one. The existing faults of the river channel have resulted from the dispersion of a large part of its flood flow from the river into the adjacent depressions on either side. The manner in which this dispersion of water has occurred, under natural conditions, was by the overpour of a thin sheet along extended bank lines, the effect of which on channel dimensions was approximately uniform, with a gradually increasing contraction as the volume of flow contained in the river was reduced progressively down stream by the increasing volume of outflow over the banks. Under these natural conditions it is probable that the channel has reached a status of approximate fixedness with perhaps a tendency to further slow deterioration.

The perpetuation of this regime, modified by a concentration of outflow at a few points as contemplated in the by-pass system, must, in the opinion of the Commission, fail as an adequate remedy for existing evils, and result in a continuance of unsatisfactory conditions.

It is a matter of common observation that when, in a silt bearing stream, a large volume of flood water is permitted to escape at one point, the resultant diminution of current energy in the channel at the point of outflow causes a marked shoaling of the river immediately below by deposit of sediment that the more enfeebled current is unable to transport.

(b) There is a strong probability that the passage of large volumes of water through wide and shallow channels may result in silting up these artificial waterways in their upper reaches and thus impair their utility.

(c) The estimated cost of this plan, upon a moderate basis as to quantities and prices, is $8,637,000 for the by-passes and $650,000 for channel correction. This does not include any estimate for constructing levees along the banks of the Sacramento River, which the plan recognizes as being necessary to confine to its channel such a volume of water as the by-passes do not provide for carrying. But it is assumed that the individual land-owners along the river are to voluntarily contribute that feature of the plan. Neither does the estimate include the cost of a number of pumping plants which are recognized as necessary to relieve basins that cannot be drained by gravity. It is also assumed that the cost of these is to be borne by local interests as well as that for leveeing Cache Slough and its tributaries for the reclamation of Yolo basin, this feature having also been omitted from their estimate as being of local concern only.

It is believed by the Commission that these assumptions are untenable as a reliance for an important part of a comprehensive system of river improvement and land reclamation; and that the cost of these features of the work necessary to be provided for must largely increase the whole estimate of cost.

(d) The by-pass plan involves the sacrifice of some 46,000 acres of land the value of which when reclaimed should be an important factor to be considered, and it is believed can be reduced to about one-fourth of that area.

THE MONTEZUMA CUT.—The proposition to make a deep cut through Montezuma Ridge for the purpose of draining Yolo basin has been condemned by all the engineers who have fully considered the case; (1) because of excessive costliness (Manson and Grunsky's estimate is over $14,000,000) and (2) because its effectiveness for the purpose in view, if the cut should be made, is a matter of doubt.

The Montezuma Ridge is a depression in the Coast Range east of Maine Prairie and lying northward of Montezuma Hills proper. It is some six miles wide and has a summit elevation of about 37 ft. above low tide. The proposed cut is to connect the lower end of Yolo basin with Montezuma Slough which is the northern projection of Suisun Bay westward of the ridge.

It is deemed useless to go into any further discussion of this proposition, especially as a logical basis for its adoption could only be found in conjunction with the by-pass system which the Commission has not considered favorably.

CACHE AND PUTAH INTERCEPTING CANAL.—The proposition to intercept the Coast Range drainage as far up as Cache Creek and convey it through a high grade canal across the Montezuma Ridge, while sustained by so able an authority as Mr. Wm. Ham. Hall, the Commission has thought proper to reject after due consideration. This project is an attractive one, if it were feasible, as an effective way to dispose of the troublesome problem of dealing with the mountain drainage on the west side of Yolo basin.

It has been estimated* that a channel 240 ft. wide with a flow 20 ft. deep should carry the water of Cache Creek to Putah Creek, a distance of 18 miles; that a channel 535 ft. wide with a depth of flow of 20 ft., should carry the Putah Creek water alone, to the summit of the Montezuma Ridge, a distance of 25 miles; and that a channel 704 ft. wide should carry the combined water of both creeks. No consideration is given to the mountain drainage other than as delivered by these two creeks.

The cut through Montezuma Ridge, six miles in length, is estimated at 13 ft. deep. The idea of making a completed canal of the above dimensions by artificial means was dismissed as being too costly for consideration. But it was proposed that an initiatory canal should be made with a top width of 30 ft., a bottom width of 10 ft., and a depth of 10 ft., 59 miles in length, at an estimated cost of $183,900, with additional cost for works to divert and regulate the flow of the creeks with the canal. It was assumed that such a canal, having a gradient of 2 ft. per mile, would enlarge and deepen itself to the required dimensions by the erosive action of the water flowing through it.†

This proposition is regarded with disfavor by the Commission for the following reasons:

(a) It is admitted that the expected process of enlarging the excavation by current action must be of indefinite time duration, and for this indefinite period the disposition of this mountain drainage is unprovided for in any manner. Some idea of the time likely to be required for the performance of this work through the agency of the

*See report of State Engineer, 1880, Part II., page 39 et seq.

†See report of State Engineer, Part II., page 39 et seq.

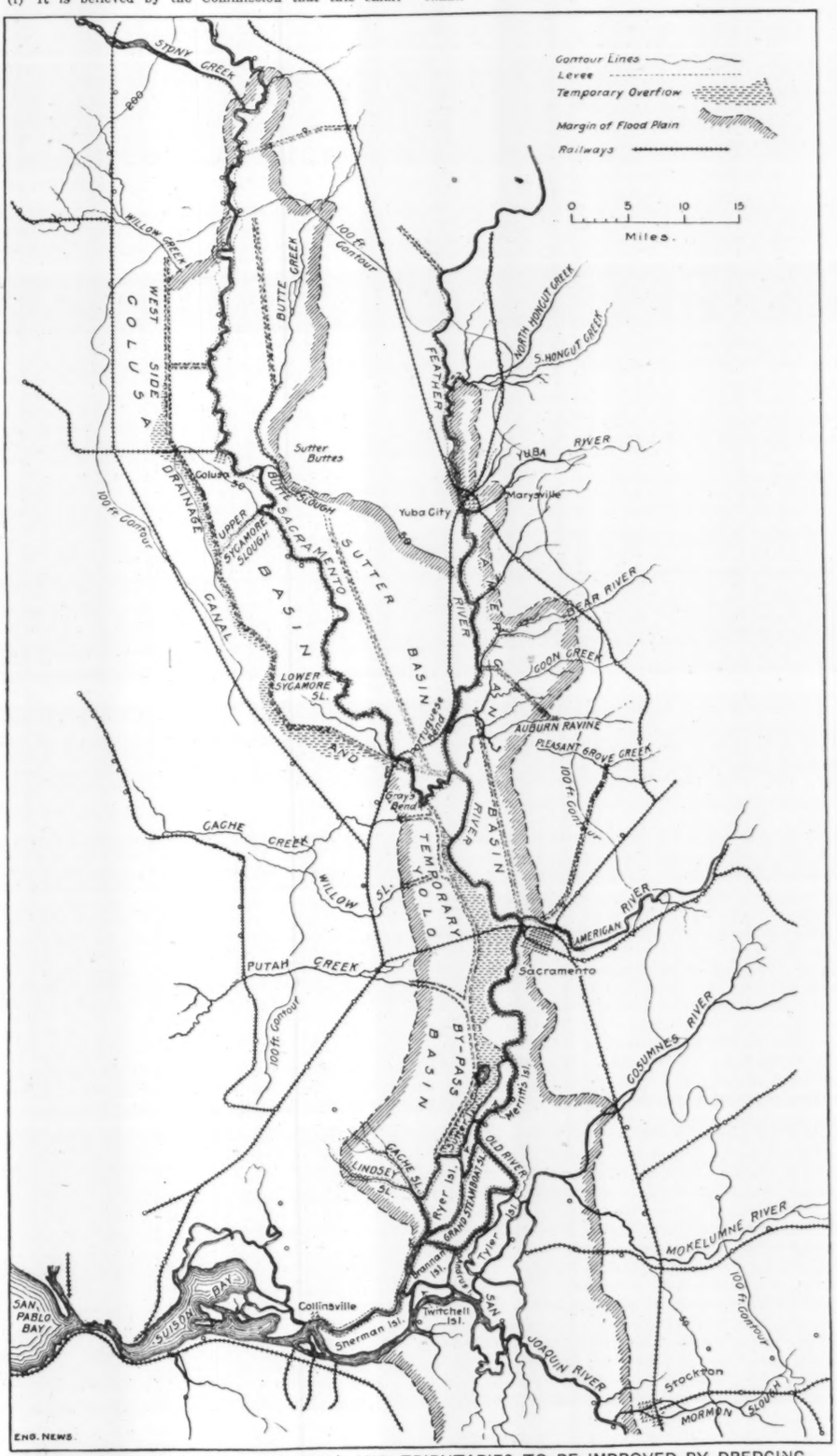
moving water is suggested by considering that the quantity of material to be thus moved is eighty or ninety millions of cubic yards, the initial cut being 59 miles long.

(b) In the expected conversion of so small an excavation into a waterway of such large dimensions by current action, no note is taken of the probable departure of the ultimate resultant channel from the alinement originally marked out for it.

(c) The conveyance of so large a mass of excavated material into Montezuma Slough must have a deleterious effect upon the waterway.

(f) It is believed by the Commission that this small cut, of such considerable length and relatively low gradient, instead of being enlarged by current erosion, must speedily be filled with the heavy matter to be carried into it from Cache and Putah Creeks, these streams having much steeper gradient, and transporting large quantities of heavy mountain debris in those portions of their courses.

(g) No note is taken of the probable existence of hard material along the line of the proposed excavation that might be an insuperable obstacle to the erosion expected to be made by the water flowing through the canal.



MAP OF SACRAMENTO RIVER (CAL.) AND TRIBUTARIES TO BE IMPROVED BY DREDGING AND DIKING.

DIVERSION OF RIVERS INTO AMERICAN BASIN.—The Commission has not gone exhaustively into a discussion of the debris problem, because its solution has been definitely taken up by the Federal and State authorities, and is now in the hands of the California Debris Commission, with work already in progress. It would, therefore, be unadvisable for this Commission to propose any plan for the treatment of the question under these circumstances. In general terms the scheme of the Debris Commission contemplates the ultimate restoration of the Yuba and Bear Rivers to something like their original channels and preventing them from spreading over such extensive areas as they do at present. The Commission regards this policy as a wise one and believes it to be a practicable one. Its inspection of the Bear River Valley showed clearly that, since the suspension of hydraulic mining, the river has been working back into a deeper and more fixed channel and has already made considerable progress in that direction. If the present tendency should be encouraged by artificial work the river can without question be confined to a single channel of small width leading directly from the foot-hills to the Feather River.

The proposition to divert the Yuba, Bear and American Rivers into the American basin, as a means of disposing of the debris problem in its relation to those streams, has received superficial attention and has been strongly advocated by a few authorities, the purpose being to use this low territory as a settling basin for the reception of this material. The Commission has given such attention to this subject as its opportunities and means of information have afforded, and the conclusion arrived at is that the plan is not a feasible one. None of its advocates seems to have considered the enormous cost of conducting the large volume of flood flow of these rivers into new channels over such considerable distances. None of them has worked out the question of gradient so as to be certain that the necessary slope, for the Yuba particularly, can be secured.

There has been no consideration of the great loss which would result from the withdrawal of the low lands of the basin from reclamation, nor any estimate of how long this withdrawal is to continue. The Commission was also informed that these sand deposits are a very poor substitute for agricultural use, for the rich soil which now covers the basin. The cost of right of way would undoubtedly be very great.

No thought appears to have been bestowed upon the condition of these rivers after performing the function of silting up American basin, nor what further measures of control and regulation may then be required; but it is apparent that if this plan could be put into execution, the permanent solution of the problem would only be deferred.

The problem of delivering the waters of these three rivers (at least 150,000 second-feet at high floods) back into the Sacramento River has evidently received only superficial consideration; but if it is to be done by means of overflow weirs which shall at the same time restrain the Sacramento River from backing up into the basin, the problem would certainly prove to be complicated, difficult and very costly.

In conclusion it is sufficient to point out that the Yuba and Bear Rivers, with their present steep gradients, have been completely filled up by mining deposits; and that an effort to divert their flow through new artificial waterways must of necessity be upon planes of much flatter slope, with the speedy result of filling the upper reaches of these new waterways with similar materials and leaving but a scant remnant of the finer matter to find its way into the bottom of American basin; besides entailing unknown complications in maintaining their flow through the upper portions of their channels.

It is believed that the necessity for relief of this character will constantly diminish unless hydraulic mining be resumed. Under present conditions the channels of the Yuba and Bear Rivers ought gradually to improve and eventually regain something like their original channels, and the quantity of debris delivered into the Feather and Sacramento Rivers ought gradually to diminish. If hydraulic mining is ever resumed on a large scale, extensive etorage would, of course, have to be provided for the heavier material; but this would have to be in the close neighborhood of the foot-hills, for it is not believed that it would be possible with any attainable slope to carry it to the lower portions of the American basin. The most that could be accomplished would be to carry down the finer material, and for this single purpose the ends would not justify the means This finer material can be carried off by the rivers if they are confined within their banks and their energy be not diminished by a dispersion of their flow.

CUT-OFF INTO THE SAN JOAQUIN.—A measure often suggested for the relief of flood conditions in the Sacramento valley is to change the course of the lower Sacramento by cutting a channel through into the San Joaquin either on the lines of the lower course of Three-mile Slough or across Sherman Island, about 1½ miles west. The first line is generally preferred.

The argument is that the Sacramento would reach tide level by the cut-off in 11.6 miles less distance than by the

present route; whatever fall or head is now required to carry the waters of the river over this distance would be saved; the flood plane at the head of the cut would be materially lowered and this lowering would extend up the river in diminishing degree for an indefinite distance.

The argument is a sound one if the San Joaquin can be considered a tidal estuary without sensible hydraulic gradient and of sufficient capacity not to be materially affected by a heavy inflow of water; and also if that capacity would remain unchanged under the new conditions. Probably the expectations of advocates of this measure would be largely realized at first, and perhaps for several years after the cut-off is made.

It is to be feared, however, that the above conditions would not continue, but that the vast quantities of silt brought down by the Sacramento would gradually fill up the estuary of the San Joaquin below the new junction, just as is already being done to a considerable extent by Three-mile Slough and to a less extent by Georgiana Slough. It seems inevitable that this must be so, in spite of the aid of tidal scour and of the current of the San Joaquin.

If this should prove to be the case the result would ultimately be to change the condition of the lower San Joaquin from that of a tidal estuary with practically no hydraulic gradient to that of a tidal river in which current will predominate over tidal action and in which there will be a pronounced hydraulic gradient. It is not likely that this gradient would ever be quite as great as that in the lower Sacramento owing to the permanent increase of volume by the addition of the San Joaquin.

Whatever high water slope might be finally developed, it would raise the flood plane at the junction of the two streams. By the same amount, or nearly so, the range of the tide above the junction of the two streams would be diminished, tidal action would be decreased, and liability to shoaling would be correspondingly increased. The net result would probably be that the present San Joaquin estuary below the new junction would fill up to the limits necessary to carry the new river, while the portion of the estuary above the junction would deteriorate as a navigable waterway—all of which would be injurious to the San Joaquin.

The question then is, on the basis of the general good, Would the gain to the Sacramento compensate for the loss to the San Joaquin? It would seem that the immediate gain would be considerable, but it is believed that it would ultimately disappear. The distance from a point in Suisun Bay a little below New York landing to the head of the proposed Three-mile Slough cut, near Zeiles Wharf, is two miles greater by the proposed channel than by the present one. Even if the ultimate slope by the new channel should be something less than by the present, the increased distance would probably effect the gain and the high water plane at the head of the cut would in time be quite as high as at present, and possibly higher than it will be if the plan of the Commission for the improvement of the Sacramento channel is carried out. The ultimate gain to the Sacramento would therefore seem to be negative. Meanwhile, unless the old Sacramento were left open, the navigation route up that river would be two miles longer than at present and three miles longer than it would be if the Horseshoe Bend cut-off were to be made. The relative cost of making the new channel and of improving the present one, and the relative cost of subsequent maintenance it is impossible to estimate closely, but the difference would not materially favor either route. On the whole the advantages to be gained by the cut-off do not appear sufficient to justify its adoption.

It has been proposed, in order to avoid the bad effects of sediment from the Sacramento, not to turn the entire river into the San Joaquin, but to make Three-mile Slough a flood relief channel of large capacity, and to construct across its head a long overflow weir of fixed height so that no water can escape while the river is below the level of its crest. Advocates of this plan assume that the heavy sediment, which travels mainly on the bottom of the river, would not pass over the weir in any considerable quantity, but would continue on down the Sacramento. Experience seems not to support this theory. The example of the Elkhorn weir, as well as experience of a similar kind on the Mississippi and other rivers, shows that the sands are drawn up and over the weir in great quantity, while, of course, matter held in suspension is carried over. Moreover, the diversion of a large volume of water from the main channel would diminish its current energy and lessen its scouring capacity. These objections equally apply to other flood relief channels that have been proposed in this vicinity.

It will be better for the San Joaquin to close Three-mile Slough entirely, and it will ultimately be better for the Sacramento as soon as its channel has adapted itself to the increased volume.

PLAN PRESENTED BY THE PRESENT COMMISSION.

Having cleared the ground by discussing the several remedial measures that have been advocated by various authorities, and which have been passed upon with disapproval by the Commission, it is now proposed to develop the plans that are to be recommended for the solution of the problem. These are:

(a) To confine the flood waters to the channels of the various streams by means of levees, so as to prevent destructive inundations of the fertile valley lands.

(b) To correct the alinement of the river by cut-offs where necessary, and to increase its channel capacity by mechanical means wherever current action fails to accomplish this purpose.

(c) To collect the hill drainage, which now loses itself in the basins, in intercepting canals and convey it into the river at selected points.

(d) To provide escape ways over the levees for surplus flood waters during the period of channel development and to provide for the disposal of this water in connection with the hill drainage.

(e) To provide for the relief of the basins from accumulation of rain and seepage water by means of pumps wherever gravity drainage is not practicable.

It should be premised that this is an undertaking of great magnitude. It cannot be expected that the work is to be consummated and these objects fully attained in a short time. Indeed, the work must of necessity be of a progressive nature, and the treatment of some of its features must be a matter of development from experimentation. While the fundamental features, as here laid down, should be adhered to, considerable latitude is to be allowed in matters of detail in carrying out these recommendations, as only by exact and accurate instrumental examinations on the ground can all the details be properly adjusted and provided for. Neither can all contingencies now be foreseen that may arise in the progress of the work which may demand modifications in the detailed operations.

Having decided upon the general scheme for river improvement, the Commission next takes up the discussion of flood discharges, and follows this discussion with recommendations as to the width and depth of channels necessary to carry the maximum floods, the location of levees. Regarding the methods of excavation, it is assumed that much of the material will be handled with dredges, but it is expected that a very large proportion of the channel deepening is to be accomplished by erosion. The report says:

> The extent of the mechanical work and the period during which it is to continue cannot be foreseen. For the purpose of making some definite estimate, it has been assumed that as the [Sacramento] channel development in general, from Colusa to the mouth of the river, two-thirds is to be removed by the agency of the current and one-third by mechanical agency; and as regards the new channel cut-offs, it has been assumed that two-thirds of the work is to be done by direct human agency and the remaining third by the flowing water. The degree of approximation to correctness of these assumptions can of course only be determined by the event.

As this plan contemplates a very large amount of work to be done by erosion, which will involve considerable caving of the river banks, the Commission assumes, as a basis for some definite etimate, that about 47 miles of river bank must be protected with simple and comparatively inexpensive revetment. The cost of this revetment, however, does not appear in the itemized estimate of cost that follows.

Since the plans submitted in this report for the general reclamation of the Sacramento valley contemplate the passage of the entire volume of river floods along their channels to Suisun Bay, it becomes necessary to make provision for draining the water which may accumulate in the low lands. The report discusses these basins in detail, showing how some of them can be drained by gravity, while others must be drained by pumping. It is recommended that all of the pumping plants be constructed on stable foundations of piles and concrete, and that the most efficient machinery be installed.

The Commission makes certain recommendations as to the administration and execution of this great work as follows: (1) There should be unity of action under one general improvement scheme. Even private parties should be required to conform their work to the general plan. (2) All the work should be under the complete control of one individual or commission responsible directly to the State. (3) If practicable, the funds for the entire work should be guaranteed from the start. Only in that way can a close following out of the scheme be effected within the estimate of cost. (4) In the order of prosecution of the work, no part should be given precedence over other parts; except that, in the case of river levees, new cut-offs and drainage canals, an upper section should not be brought to completion in advance of a lower section. (5) Measures should be taken at once to start a preliminary survey, since the data upon which the Commission bases its estimates are only reasonable approximations to the truth. Flood discharges should be measured. (6) The administrative authority should be vested by law with power to secure right of way by peremptory processes which will eliminate undue delay.

The following is the Commission's estimate of cost:

ESTIMATES.—The question of fixing unit prices upon which to arrive at an expression of the cost of the work recommended to be done is perhaps the most difficult one that presents itself for decision; yet upon this one fact must directly depend the important matter of the sum total of the estimate of cost. The earth work in its various forms constitutes by far the largest part of the subject to be considered, and there is no certain basis known to the Commission upon which to fix unit prices to represent the cost of the different characters of the work of this class. From statements made by persons whose experience in this kind of work gives value to their expressions, the Commission is led to believe that, under proper management, a large part of the excavation and levee building can be done at as low a cost as 3 or 4 cts. a cubic yard through the agency of large dredges.*

The current contract prices that have come to the attention of the Commission generally very much exceed these figures, and it is believed that a great advantage might be realized in the saving of cost by the instalment of a large dredging plant by the state authorities, to be operated under the direction of the officials who are to administer the work of improvement, sufficient to do a considerable part if not the whole of the dredging. Such an instalment, if only applied in part, would act as a salutary restraint on the prices bid by contractors.

The large masses of excavation to be made in the cut-offs must necessitate the conveyance of the material to considerable distances, placing the bulk of it outside the reach of the ordinary clam-shell dredge. It is believed that hydraulic dredges, or other modern machinery, can be utilized for this class of work, and that it can be so handled at a price not far from 15 cts. per cu. yd., or possibly less. The large quantity of work to be done will serve as a stimulus to contractors to devise the least costly methods of operating and will justify the installation of expensive plant.

A considerable part of the levee work must also be done by teams and scrapers on ground that is inaccessible to dredges and not sufficient in bulk to justify the application of other means. This character of work, it is believed, ought not to exceed an average cost of 12½ cts. per cu. yd.

The foregoing considerations have led to the adoption of the prices for earthwork as tabulated below.

RIGHT OF WAY.—The item of right of way will prove a costly feature of the work. In endeavoring to arrive at a unit value per acre to represent the cost of this item, consideration was given to the great diversity of land values that obtains in different parts of the valley, ranging from low to very high valuations in different localities; also to the costly improvements that must be invaded in places. After due consideration an average price per acre of $125 was adopted.

In this connection it may be stated that along that part of the Sacramento River extending from Stony Creek to Colusa it will be necessary, as before noted, to clear the timber from a space along the river banks in order to afford a wider unobstructed waterway for the passage of the floods. It is estimated that 3,200 acres of wood and brush land must be so cleared and the right to exercise such measure of control over this land must be acquired. As the use of the land in this class for cultivation or pasturage will not be impaired nor interfered with, it is believed that an average price not exceeding about $25 per acre will cover the cost of this item.

Owing to the uncertainty as to unit prices and the probability that many small items have been overlooked in the general estimate, the item of "Administration and contingencies" is taken at 15% instead of the more usual 10%.

TABLE OF ESTIMATES.

Levees.			
Sacramento River and tributaries:			
Collinsville to foot Grand Island	1,773,000 cu. yds.		
Head Grand Island to foot Grand Island:			
Via Steamboat Slough	2,130,000 "	"	
Via Old River	1,422,000 "	"	
Head Grand Island to American River	6,081,000 "	"	
American River to Feather River	2,961,000 "	"	
Feather River to Colusa, along existing channels	13,305,000 "	"	
	27,672,000 "	" @10c.	$2,767,200
Feather River to Colusa, along cut-offs	9,300,000 "	" @15c.	1,395,000
Colusa to Stony and Chico Creeks	12,450,000 "	" @12½c.	1,556,250
Total			$5,718,450

*The term "dredge" is in general use in the United States east of the Rocky Mountains and is accepted by the engineering profession; that term is therefore used in this report instead of "dredger," which is in use in California.

Feather River and tributaries	11,720,000 cu. yds.	@10c.	$1,172,000
American River	532,000 " "	@10c.	53,200
			$6,943,650
Less 1,000,000 cu. yds. at an average price of 11 cts.			110,000
			$6,833,650

COST OF CHANNEL DEVELOPMENT.

To be removed from channel.	Already allowed for in levee estimate.	Remainder to be estimated for.	Price.	Cost.
Collinsville to foot Grand Island.				
19,117,000	1,773,000	17,344,000	7c.	$1,214,080
Foot Grand Island to head Grand Island.				
19,450,000	2,130,000	17,320,000	8c.	$1,385,600
Head Grand Island to American River.				
33,000,000	3,000,000*	30,000,000	8c.	$2,400,000
American River to Feather River.				
10,000,000	2,000,000*	8,000,000	8c.	$640,000
Feather River to Colusa—Existing Channels.				
15,900,000	10,000,000*	5,900,000	10c.	$590,000
Feather River to Colusa—along Cut-offs.				
9,567,000	9,300,000	267,000	15c.	$40,050
Bank revetment, 250,000 lineal feet @$4				$1,000,000
				$7,269,730

WEST-SIDE CANAL:

Yolo canal	15,840,000 cu. yds.	@ 7c.	$1,108,800
Casche slough	1,716,000 "	@ 7c.	120,120
Putah creek	940,000 "	@ 8c.	75,200
Willow creek	412,000 "	@ 8c.	32,960
Cache creek	436,000 "	@ 8c.	34,880
Gray's Bend cut	2,646,000 "	@15c.	396,900
Knights Landing cut.	4,285,000 "	@15c.	642,750
Colusa basin	5,800,000 "	@ 8c.	464,000
Wallace's Crossing to opposite Caldens	2,464,000 "	@ 8c.	197,120
Caldens to Willow C'k	1,030,000 "	@ 8c.	82,400
			$3,155,130

The following work included in above estimates will not be required until the final stage of the development:

Raising of west side embankment on an average of about 5 ft. from a first height of 12 to 13 ft.; say 8 cu. yds. per running foot for 25 miles; 1,056,000 cu. yds. @ 7c.	$73,920
East side embankment, Yolo basin, 7,970,000 cu. yds, @7c.	557,800
West side embankment, Colusa canal 2,900,000 cu. yds. @8c.	232,000
West side embankment, Wallace's Crossing, to opposite Caldens Landing	98,560
	$962,280

Drainage of the Basins:

Butte basin canal	400,000 cu. yds.	@8c.	$32,000
Sutter basin canal	2,148,000 "	@8c.	171,840
American basin canal	590,000 "	@8c.	47,200
			$251,040
Pumping plants, 700,000 gallons per minute			420,000
			$671,040

Easement Weirs:

Main structures	$500,000
Timber spillway (Fremont weir)	12,000
Levees from weirs to west side canal, 2,234,000 cu. yds. @8c.	23,400
Total	$735,400

Intercepting Canals:
(Butte, Auburn Ravine, Pleasant Grove Creeks.)
Excavation, 2,880,000 cu. yds., @8c. $230,400

Bridges:
New bridges, and old bridges changed $500,000

Land Damages:
Acreage required, 10,000 acres @ $125,000 $1,250,000

Telephone Lines:

Copper wire, 56,000 lbs. @16c.	$8,960
Poles, 8,000 @ $1.50	12,000
Telephones, 41 @ $12	492
Erection of line at $40 per mile, 200 miles	8,000
	$29,452

Summary:

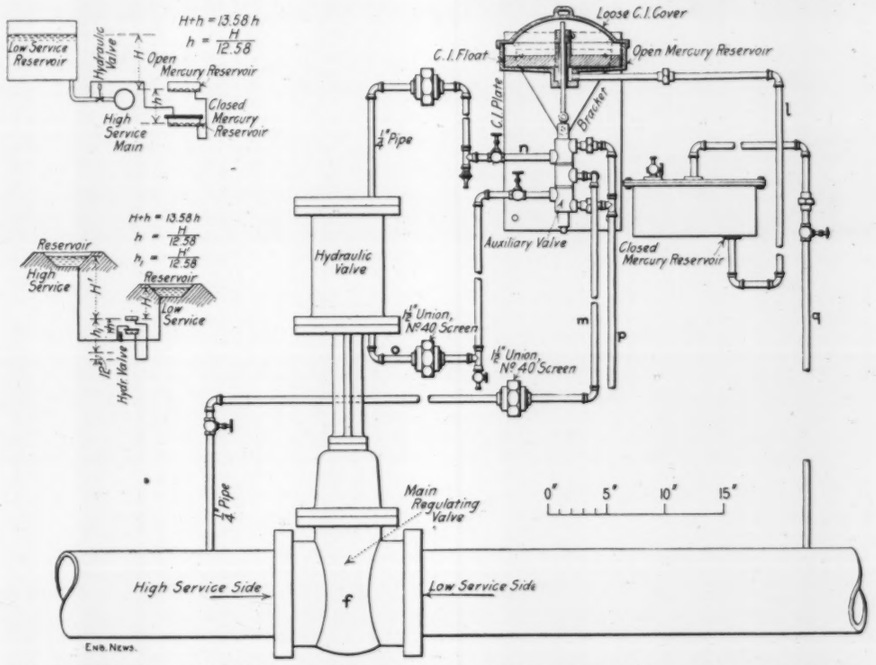
Levee construction	$6,833,650
Channel development	7,269,730
West side canal	3,155,130
Drainage of basins	671,040
Easement weirs	735,400
Intercepting canals	230,400
Bridges	500,000
Land damages	1,250,000
Telephone line	29,452
	$20,674,802
Add for administration and contingencies, 15%.	3,101,220
	$23,776,022

AN AUTOMATIC REGULATING VALVE FOR RESERVOIRS OR STAND-PIPES SUPPLIED FROM A HIGHER ELEVATION.

By J. W. Ledoux,† M. Am. Soc. C. E.

The accompanying illustration shows a device that we have had in operation for several years. The purpose of this device is to automatically regulate the height of water in a distributing reservoir or stand-pipe, when said water is flowing from another reservoir or intake at a higher elevation.

Suppose, for instance, a town gets its water supply by gravity from a lake or stream situated ten miles distant and 500 feet higher than the streets. A convenient pressure on the town would be, say, 100 lbs. per sq. in., but the lake pressure would be over 200 lbs. per sq. in., which is too much for satisfactory service. Pipes to stand this pressure would be too costly, and besides, ordinary plumbing fixtures and fire hose would hardly stand it. To overcome the difficulty, a distributing reservoir is built as near the town as possible, and at an elevation 200 ft. higher. If there is a surplus of water and a means for the disposal of waste water from the distributing reservoir, it can be allowed to overflow, but usually good water at a high elevation is scarce, and often it is inconvenient to take care of the overflow. For unimportant cases, and in warm weather, a float suitably attached to a balanced or butterfly valve can be arranged to throttle or shut off the supply main when the reservoir is filled to the desired height; or in more important cases, there can be stationed at the distributing reservoir a man who regulates the supply by an ordinary gate valve; but for various reasons these are objectionable. There are on the market automatic regulating valves operated by piston or diaphragm with spring or weight, but these are not very sensitive, and permit of a variation of water level from 2 to 10 ft.



AN AUTOMATIC VALVE FOR CONTROLLING THE WATER LEVEL IN A RESERVOIR OR STAND PIPE SUPPLIED FROM A HIGHER ELEVATION.

The apparatus herein shown is fully as sensitive, and has all the advantages of a float type of regulating valve, and is at the same time free from its objections.

A regulating valve is set in the main pipe connecting the two reservoirs and is operated by a hydraulic valve set above it which, in turn, is raised or lowered by water admitted to and from a five-way auxiliary valve by means of a superimposed float. This float is in an open mercury reservoir, which is connected with a closed mercury reservoir under pressure from the low-service side of the hydraulic valve. The high-pressure side of the regulating valve is connected with the five-way auxiliary valve and the latter is also connected with both the upper and lower sides or ends of the hydraulic valve.

The operation of the apparatus may be followed in detail by referring to the large diagram in the accompanying illustration.

Water flows in the direction of the arrow into a reservoir or stand-pipe until said reservoir or stand-pipe is full or the elevation of water in same is at the desired height. The pressure due to this height acts on the closed or lower mercury reservoir through the pipe q; the mercury passes up through the pipe l into the float chamber or open mercury reservoir, raising the float and operating the auxiliary five-way valve so as to permit water to pass through the pipes m and n into the upper portion of the hydraulic cylinder, and at the same time the bottom of said hydraulic cylinder drains through the pipe o back through the auxiliary valve and out of the waste pipe p, which in many cases may be connected with the low-service side of the main valve. This operation closes the main valve. When the reservoir lowers a few inches the float will fall and the auxiliary five-way valve will operate so as to permit water to pass through pipe m and through the auxiliary valve and through pipe o to the bottom of the hydraulic cylinder, and at the same time drain the top of said cylinder through pipe n through auxiliary valve and through waste pipe p, thus opening the main valve. At the three points indicated are placed couplings containing therein metal screens which prevent dirt from getting into the auxiliary valve.

In some cases this apparatus is operated by having the pipe q connected on the opposite side of the main valve. In this manner water will flow into the reservoir or stand-pipe until it is full, when the valve will close as before. It will open just as soon as the pressure on the high-service side falls to a point equal to what it would be if the valve were open, and the reservoir were drawn down a few inches. This is frequently the case, and is particularly useful where there is a large consumption on the high-service side of the hydraulic valve. Theoretically, it would be desirable to have the hydraulic valve of the balanced type, in which case the hydraulic cylinder could be very much smaller. For ordinary cases we usually specify the hydraulic cylinder 2 ins. larger in diameter than the valve.

It is evident that the regulating valve need not be the full size of the main; in fact, it is an advantage to have it smaller. It could be as small as one-third the diameter, and connected to the main pipe with reducers or otherwise. By means of the small diagrams the apparatus can be located to suit the conditions and elevations existing in any particular case.

It will be seen that the auxiliary apparatus is mounted on a plate, and the upper mercury reservoir can rest on a suitable support fixed at the required height.

It is evident that the regulating apparatus and auxiliary valve can be placed at any required distance from the main valve. Usually we place the apparatus in a gate chamber or basement of a gate house.

We have had this apparatus in regular opera-

*Arbitrary proportions of the total levee volumes on these reaches have been taken because it is not probable that all the levees can be built from the channel excavation. The proportions assumed are based upon existing conditions on the reaches in question.

†Chief Engineer The American Pipe Mfg. Co., 112 North Broad St., Philadelphia, Pa. The device has been patented by Mr. Ledoux.—Ed.

tion on many of our plants, and it works with absolute certainty. By its use the level of water in the reservoir can be controlled to within from 1 to 3 ins. from the mean level. In one case that we have watched closely the valve continued to act for two years without a single failure.

The price of the apparatus, exclusive of small pipe fittings and hydraulic valve, is about $100.

A TRAVELING FORM FOR CONSTRUCTING THE INVERT OF CONCRETE SEWERS.

By Robert R. Evans,*

Considerable use has been made during the past year of a traveling form for constructing the inverts of concrete sewers built in the city of Haverhill, Mass. This form is a modification of one used during the previous year, and the motive for the construction of the original form was as follows:

A 30-in. circular sewer was to be built in a section of the city where it was known that a loose gravel, suitable for concrete, would be encountered for the full depth of the trench, which varied between 12 and 14 ft. The presence of this gravel made the use of concrete especially desirable, but it was thought that its loose nature would cause it to cave off from the sides of the trench and fall beneath the forms, if of the ordinary pattern, before the concrete could be deposited. On the other hand, to sheet the trench to the bottom and fill the entire space with concrete would require an excess of material. Accordingly, a form was devised by the writer in which a steel shell of ¼-in. plate bent to the desired shape of the outside of the concrete section was used to support the excavation and to retain the concrete, and was forced ahead by a jack, a short distance at a time, as fast as the concrete was deposited.

The successful use of this form led the writer to design another, to accomplish the same end, but with some changes in the form of construction which use had suggested to him, and this was used during the past season for the construction of the invert of a 24-in. sewer in a locality where, for the greater part of its length, the bottom might have been excavated to the desired section and ordinary forms used.

Briefly described, this latter form was made as follows: A plate of steel ¼-in. thick and 6 ft. 2 ins. long was bent to a semi-cylinder with an inside radius of 18 ins., and the sides extended on a tangent to the curve, about 6 ins. above the plane of the horizontal diameter. The front, open, end was stiffened by a curved 3-in. angle-iron riveted to it, with a horizontal angle-iron riveted across its upper ends, while the rear, open, end was held apart by a 2 × ½-in. iron bent down at the ends, and riveted to the inside of the steel plate near its top edges. Along the inside of the shell thus formed longitudinal 1½-in. angle-irons were riveted with the horizontal leg up, and 1½ ins. above the horizontal diameter. These angle-irons served as tracks, or ways, for the support of the inside or core forms.

The inside forms were made in 3 ft. lengths, and consisted of two ribs made of 2-in. plank, to which narrow strips of wood were nailed, forming a semi-cylinder which was covered with sheet iron. To facilitate lifting these forms out of the concrete, their upper edges were spread about ¼-in. from a true semicircle. Along the inside bottom of each form a 4 × 6-in. timber extended from end to end, passing through the ribs, which were fastened to it, and a projection on the top of this timber on the rear end of the form prevented the front end of the following form from lifting above it. When all the forms were in place this timber formed a continuous column for their entire length, against which the jack acted in forcing ahead the outer form. Across the top of each rib a 3 × 3-in. oak timber was fastened, projecting 6 ins. beyond the sides of the inner form, at such a height that when this inner form was dropped into the steel shell it was held suspended concentrically within the outer form, leaving an annular space of 6 ins. in which to place the concrete. It will be readily seen that the inner form was then free to slide out at the rear end of the outer form, while still retaining its concentric position in relation to it.

A partition of 3-in. plank fastened to the back of the curved angle-iron in the forward end of the outer form, in which was bolted the base of an ordinary track jack, and a second movable partition to receive the thrust of the head of the jack, and made of two layers of 3-in. plank, fitting loosely in the outer form, and hung from a cross-bar sliding on the longitudinal ways, completed the essential parts of the outfit.

In use the outer form was placed in the trench which had been excavated to the proper depth, and set to the line and grade. One of the inner forms was then dropped in, resting on the ways, and the movable partition brought against the forward end of this inner form, and held there by slightly tightening the jack. Concrete was then deposited in the annular space between the two forms and rammed by a curved iron rammer. The jack was then brought into action, and with its base bolted, as previously stated, to the forward partition fixed in the outer form, and with its head reacting against the movable partition, which in turn reacted against the ends of the forward inner form, and of the newly-made concrete section, forced the outer form ahead.

When starting the work it was manifestly necessary either that the concrete be abutted against the end of the trench or some other unyielding surface at the open end of the form, or that the inner form be braced against movement; but after a few feet of invert had been completed it was found best not to provide any bracing to prevent movement of the inner forms, in order that the pressure, being thus borne by the concrete alone, would force the concrete into any depressions which might occur. A second ramming of the concrete as the rear end of the outer form passed from under it practically prevented any movement of the inner forms, and forced the concrete into any such voids, but under favorable conditions the movement was so slight that even this precaution was not necessary.

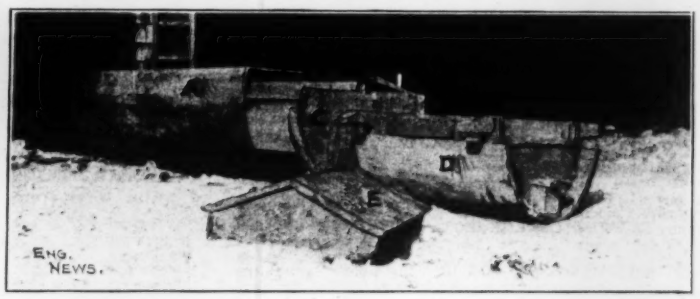
As the jack used on this work would open only about 9 ins., it was necessary to use three blocks of 9, 18 and 27 ins. in length, in order to get the forward movement of 3 ft. necessary before another form could be inserted. The movable partition was, of course, pulled ahead before inserting a second inner form. Eight of the inner forms were used, giving a total length of 24 ft., and when all had been put in place the rear one was brought forward as needed.

A simple clamp, consisting of a bent rod passing over the projecting supports of the inner forms and looking beneath the angle-iron ways was used on each side to prevent the inner form from rising when the concrete was rammed beneath it, and to facilitate the placing of the concrete a pitch roof, covered with iron, was placed over the forward inner form, and the concrete, being dumped on this roof, either slid or was easily pushed into place by the rammer.

The various parts of the form are shown in the accompanying views, on each of which the parts are designated as follows: A, outer form; B, fixed partition in forward end of outer form, furnishing bearing for the base of the jack; C, movable partition; D, inner forms, only two of which are shown; E, roof used on forward inner form to facilitate spreading concrete; F, bent rods or clamps to hold down inner forms. Fig. 1 shows the various parts of the forms separately. Fig. 2 shows the same arranged in the order in which they are to be assembled, and Figs. 3 and 4 each show the parts assembled ready for use, the former being a view from the rear and the latter from the forward end. The clamps are shown in the first view only, as their use is apparent, and they are too small to show effectively in the photograph. The jack, which as before stated, was an ordinary track jack, was not available for the photographs, but the fourth view shows very plainly the space which it would occupy between B and C.

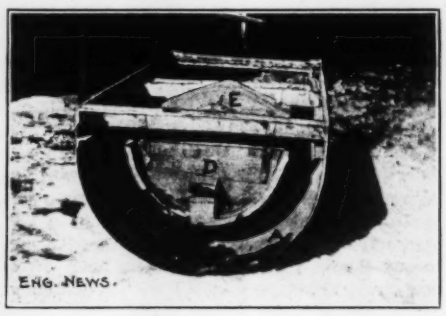
An ordinary level was used on the forward end of the outer form, to assist in keeping it level transversely. Two men managed the forms, one alternately ramming the concrete into place and working the jack, while the other assisted in bringing up the forms from the rear and shaped

Form Completely Dismantled.

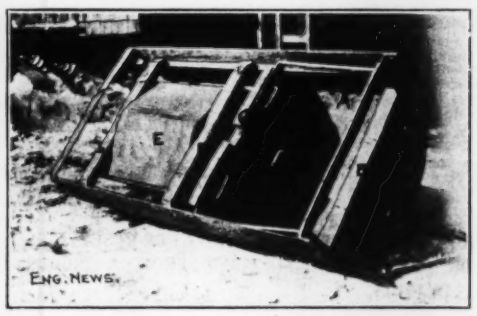


Parts in Position for Assembling.

FIG. 1. VIEW SHOWING COMPONENT PARTS OF TRAVELING FORM FOR CONCRETE SEWER INVERTS.



View of Rear End.



View of Front End.

FIG. 2. VIEW SHOWING TRAVELING FORM FOR CONCRETE SEWER INVERTS ASSEMBLED AND CONNECTED UP.

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out the trench just ahead of the form, practically one-half the time of each being consumed in moving the forms. For the concrete, the small or nut size of broken stone from the city quarry was used in the proportion of 1-3-5. A mixture was used wet enough so that when placed in the space on one side only of the form it could be easily forced up on the other side by the rammer.

No especial difficulty was experienced in keeping the form to line and grade, with a good straight trench and a little care in getting the form properly alined at the start, and while one man worked the jack, the other, with a lever bearing under the forward end of the outer form, easily corrected any tendency to vary from line or grade, and kept it level transversely. As the grade of this particular sewer was 6.6%, some precautions were not taken in this matter, which would be necessary in flatter grades.

As the actual work of building sewers in this city is under the charge of the Superintendent of Highways, and not of the Engineering Department, I am unable to give the itemized cost of the whole work, but from my own notes taken at the time I find that the cost of the first piece of the sewer built with this form was as follows, it being understood that some delays occurred during the first day or two on account of the unfamiliarity of the men with these forms: Total length of concrete invert, 265 ft. Theoretic quantity of concrete in invert 6 ins. thick, 19.3 cu. yds. Total number of hours labor, one man, mixing and placing concrete, and setting and moving forms, including trimming bottom of trench ahead of forms, 221 hours at 25 cts. per hour, which is equivalent to $2.86 per cu. yd., or $0.21 per lin, ft. This cost was divided as follows: Labor, setting and moving forms alone, 42 hours at 25 cts., or $0.67 per cu. yd., or $0.05 per lin ft., leaving the balance of $2.19 per cu. yd., or $0.16 per lin. ft. as the cost of mixing, wheeling and placing concrete, including some trimming of the trench, and washing over the completed section with neat cement.

The bottom of the trench on this portion of the work was hard and full of rocks, and required to be excavated slightly larger than the outside form, the space being filled in with gravel tamped in from the forward end. When this tamping and filling with gravel was carefully done, the amount of concrete used could not, of course, be in excess of that necessary to form a 6-in. half ring, but as the work was done by the day, there was a tendency to omit to carry the gravel up to the full height of the concrete, and these side spaces were filled by the addition of concrete at the time of tamping behind the form, previously referred to, as this was easier. Even in these portions of the work, however, which were particularly unfavorable in this style of form, there was less concrete used than would have been the case with the ordinary forms, provided the walls had been made nowhere less than the required 6 ins.

The advantages of a form such as that described are, of course, greatest in loose material, which would with ordinary forms necessitate the use of more concrete, but aside from this consideration there seems to be a better opportunity to ram the concrete, as the outer form guides the rammer beneath the inner form, the concrete being rammed is confined at both ends, and finally the pressure exerted in forcing the outer form ahead tends to consolidate the concrete in a direction at right angles to the direction of ramming. An unscrupulous workman cannot reduce the thickness of the wall to save work, and only a short section 3 ft. in length in the form above described is exposed to the falling of material between the forms, and even should this occur it is the work of but a few moments to take up the forward section of the inner form, remove the obstruction and replace the section.

No reinforcement was used on the work described, but should it be desired, there would seem to be nothing to hinder its use; by providing holes in both partitions wherever longitudinal reinforcement might be required, rods of any length could be used. Steps have been taken toward securing a patent on some of the features of the above form which are thought to be novel.

DETERMINING THE CAPACITY OF A CYLINDRICAL GRAIN BIN WITH ECCENTRIC CONICAL HOPPER.

By B. F. Groat.*

Since the advent of cylindrical bins in large numbers for storage of grain and other commodities, it will be of interest to exhibit a general formula and method for determining the capacity of a cylindrical bin with eccentric conical hopper, the side elevation of which is shown in Fig. 1.

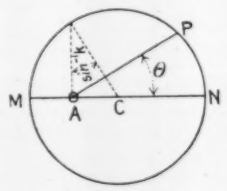

Fig. 2. Plan.

Plan and Elevation of Circular Grain Bin with Eccentric Hopper.

It will be observed that the volume of the bin differs from the volume of the circumscribing cylinder of the same height and diameter only by the volume cut off by the conical hopper. Hence, it will be necessary only to find the volume cut off and subtract this from the circumscribing cylinder.

PROOF OF THE FORMULA.

The volume cut off may be generated by a triangle rotating about the vertex or apex of the hopper, the base being a horizontal eccentric radius from the vertex to the side of the cylinder, the height lying in the side of cylinder and the hypothenuse being an element of the cone. If this triangle rotate through half a revolution from the position of longest to the position of shortest base, it will generate half the volume cut off by the hopper. By the theorem of Pappus the volume generated by the triangle in rotating through the arc $d\theta$ is

$$\frac{\tan \phi}{3} \rho^3 \, d\theta = \frac{a}{3} \rho^3 \, d\theta.$$

Hence the volume cut off is twice the sum of these elements of volume for half a revolution of the triangle; that is,

$$\text{Volume cut off} = V_o = \frac{2}{3} a \sum \rho^3 \, d\theta; \text{ where } a = \tan \phi = \text{slope of hopper, } \rho = \text{base of triangle} = \text{eccentric radius.}$$

Looking upon the plan of bin, Fig. 2, we see the center of bin at C, center of hopper at A, while any eccentric radius as AP is a base of the variable triangle $= \rho$. From analytic geometry, taking $PAN = \theta$, we have

$$\rho = b \cos \theta + \sqrt{R^2 - b^2 \sin^2 \theta} = R (k \cos \theta + \sqrt{1 - k^2 \sin^2 \theta}),$$

where R = Radius of bin, b = AC = distance of center of hopper from center of bin, and $k = b \div R$.

$$\text{Therefore } V_o = \frac{2}{3} a R^3 \int_o^\pi (k \cos \theta + \sqrt{1 - k^2 \sin^2 \theta})^3 \, d\theta.$$

Cubing and observing that $\int_o^\pi \cos^3 \theta \, d\theta = 0$,

$$\int_o^\pi \cos \theta \, d\theta = 0, \quad \int_o^\pi \sin^2 \theta \cos \theta \, d\theta = 0,$$

we find, after rationalizing by means of elliptic functions, that

$$V_o = \frac{4}{9} a R^3 [(k^2 + 7) E - 4 (1 - k^2) K]$$

where E and K are the complete elliptic integrals usually designated by these letters; see Table I.

Thus far we have considered the hopper to be a cone, but the mouth of the hopper truncates the cone in practice. This is equivalent to dropping the cone a certain amount and cutting off a corresponding portion at the bottom. Thus, if the cone were dropped h_2 ft. the increase in volume would be

$$\pi R^2 h_2 - \frac{\pi}{3} \frac{h_2^3}{a^2}.$$

If the hopper-mouth be circular and of radius r, then $h_2 = r a$, and the increment of volume would be

$$\pi a R^2 r - \frac{\pi}{3} a^2 r^3.$$

Let this increment in volume be I; then

$$I = \pi a R^2 r - \frac{\pi}{3} a r^3 = \pi R^2 h_2 - \frac{\pi}{3} \frac{h_2^3}{a^2}$$

THE FORMULA.

If V be the required capacity of the bin, then, from the foregoing, the formula for the capacity is

$$V = \pi R^2 (h + h_2) - \left(V_o + \frac{\pi}{3} r^2 h_2\right)$$

$$= \pi R^2 (h + h_2) - \left(V_o + \frac{\pi}{3} \frac{h_2^3}{a^2}\right).$$

$$V_o = \frac{4}{9} a R^3 [(7 + k^2) E - 4 (1 - k^2) K]$$

TABLE No. I.

Values of the Complete Elliptic Integrals, K and E, for Different Values of the Modulus, k.

(Taken from Peirce's Table of Integrals.)

sin⁻¹k	K	E	sin⁻¹k	K	E
0°	1.5708	1.5708	45°	1.8541	1.3506
1°	1.5709	1.5707	46°	1.8691	1.3418
2°	1.5713	1.5703	47°	1.8848	1.3329
3°	1.5719	1.5697	48°	1.9011	1.3238
4°	1.5727	1.5689	49°	1.9180	1.3147
5°	1.5738	1.5678	50°	1.9356	1.3055
6°	1.5751	1.5651	51°	1.9539	1.2963
7°	1.5767	1.5649	52°	1.9729	1.2870
8°	1.5785	1.5632	53°	1.9927	1.2776
9°	1.5805	1.5611	54°	2.0133	1.2681
10°	1.5828	1.5589	55°	2.0347	1.2587
11°	1.5854	1.5564	56°	2.0571	1.2492
12°	1.5882	1.5537	57°	2.0804	1.2397
13°	1.5913	1.5507	58°	2.1047	1.2301
14°	1.5946	1.5476	59°	2.1300	1.2206
15°	1.5981	1.5442	60°	2.1565	1.2111
16°	1.6020	1.5405	61°	2.1842	1.2015
17°	1.6061	1.5367	62°	2.2132	1.1920
18°	1.6105	1.5326	63°	2.2435	1.1826
19°	1.6151	1.5283	64°	2.2754	1.1732
20°	1.6200	1.5238	65°	2.3088	1.1638
21°	1.6252	1.5191	66°	2.3439	1.1545
22°	1.6307	1.5141	67°	2.3809	1.1453
23°	1.6365	1.5090	68°	2.4198	1.1362
24°	1.6426	1.5037	69°	2.4610	1.1272
25°	1.6490	1.4981	70°	2.5046	1.1184
26°	1.6557	1.4924	71°	2.5507	1.1096
27°	1.6627	1.4864	72°	2.5998	1.1011
28°	1.6701	1.4803	73°	2.6521	1.0927
29°	1.6777	1.4740	74°	2.7081	1.0844
30°	1.6858	1.4675	75°	2.7681	1.0764
31°	1.6941	1.4608	76°	2.8327	1.0686
32°	1.7028	1.4539	77°	2.9026	1.0611
33°	1.7119	1.4469	78°	2.9786	1.0538
34°	1.7214	1.4397	79°	3.0617	1.0468
35°	1.7312	1.4223	80°	3.1534	1.0401
36°	1.7415	1.4248	81°	3.2553	1.0338
37°	1.7522	1.4171	82°	3.3699	1.0278
38°	1.7633	1.4092	83°	3.5004	1.0223
39°	1.7748	1.4013	84°	3.6519	1.0172
40°	1.7868	1.3931	85°	3.8317	1.0127
41°	1.7992	1.3849	86°	4.0528	1.0086
42°	1.8122	1.3765	87°	4.3387	1.0053
43°	1.8256	1.3680	88°	4.7427	1.0026
44°	1.8396	1.3594	89°	5.4349	1.0008

EXAMPLE.

Find the capacity, in cubic feet, of a cylindrical bin with eccentric conical hopper having a mouth 2 ft. in diameter at the bottom, the other dimensions of bin being:

Height (inside) above bottom of hopper = h = 30 ft.; diameter (inside) of cylinder = 2 R = 20 ft.; center of hopper 6 ft. from axis of bin = eccentricity = b = 6 ft.; eccentricity ratio = b ÷ R = 6 ÷ 10 = 0.6; radius of hopper-mouth = r = 1 ft.; slope of hopper must be large enough so the contents will flow, that is, the slope must be greater than the natural angle of repose of the material. Take slope = tan φ = a, where φ is greater than the angle of repose, say in this problem that tan φ = a = ⅔ = 0.667; depth of vertex of cone below bottom of hopper = h_2 = a r = 0.667 × 1 = 0.667.

Solution: Substituting in the formula for V_o we find

$$V_o = \frac{4}{9} \times 0.667 \times 10^3 (7.36 E - 2.56 K)$$

$$= 0.2964 \times (7.36 \times 1.418 - 2.56 \times 1.751)$$

$$= 1,764 \text{ cu. ft.}$$

The values of E and K are taken from Table I. by interpolation. Opposite the angle having k = 0.6 for its sine, we find E and K. This angle may be found either from a table of natural sines or by direct measurement from a graphic construction similar to Fig. 2. In this problem

$$\sin^{-1} .6 = 36° 52'.$$

Substituting now in the formula for the required capacity, V, we find the total volume to be

$$V = 3.142 \times 100 \times 30.67 - (1764 + \frac{3.142}{3} \times 0.67)$$

$$= 9,636 - 1,764.7$$

$$= 7,871 \text{ cu. ft.,}$$

which is the required capacity of the bin.

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ECONOMICAL CONSTRUCTION OF REINFORCED CONCRETE BEAMS AND FLOOR SLABS.

By Charles R. Steiner.*

In selecting economical shapes for ordinary steel structures, the minimum quantity of material which, for beams, is nearly in proportion to the cross-sectional area must be found. For reinforced concrete beams, however, the cost of the two resisting materials must necessarily be taken into account. The writer has, therefore, prepared a table, which is subject to correction as regards the constants therein assumed, but is submitted as a fair review of the most suitable sizes for varying maximum moments.

In preparing this table the ordinary bending theory has been adhered to. It is assumed that a plane cross-section at the most dangerous place will be dislocated (with respect to the fixed end tangent of the segment under consideration) by swinging into another plane around a neutral axis; further, that the steel resists for tension and the concrete for compression only. Let

c = the average unit strain of the concrete.
f = the average unit strain of the steel.
w = the width of the beam.
m = the distance from neutral axis to extreme compression-fiber.
n = the distance from neutral axis to the center of steel-rods.
x = the expansion of the steel for the unit strain f.
y = the compression of the concrete for the unit strain c.
Z = the compression of the concrete for the maxim unit strain at the extreme fiber.
E_c = Coefficient of elasticity of concrete.
E_s = Coefficient of elasticity of steel.

Then the maxim strain of the concrete is 2c.

Further, $Z = 2y$; also,

$$x = \frac{f}{E_s},$$

$$y = \frac{c}{E_c},$$

$$Z = \frac{2c}{E_c}, \text{ and}$$

$$\frac{m}{n} = \frac{Z}{x} = \frac{2c}{E_c} \times \frac{E_s}{f};$$

further, the maximum moment allowed by the resistance of the concrete,

$$M = w \times m \times C \left(\frac{2}{3}m + n\right)$$

The constants are assumed as follows: Maxim strain in concrete 2c = 200 lbs.; hence, c = 100 lbs.

$$\frac{E_s}{E_c} = 12; \text{ hence,}$$

$$\frac{m}{n} = \frac{200 \times 12}{f} \text{ or } f = \frac{n}{m} \times 2400.$$

As for the cost, it is assumed that 1 sq. ft. of concrete 1 in. thick costs 3 cts., and 1 sq. in. of steel 1 ft. long costs 10 cts.

Under these assumptions, which may easily be modified according to circumstances, the table gives for various values of $\frac{m}{n}$, and consequently various unit strains f of the steel, the bending moments, the cost of the steel, the cost of concrete, and the total cost per lin. ft. for various thicknesses or depths, the width of the beam being 1 ft. (To find the area of the required steel rods one-tenth of the number of cents given for cost of steel must be taken.)

As far as this table reaches, it will appear that for the smaller moments the unit strain of the steel should be selected from 6,000 to 8,000 lbs. per sq. in., and for the larger moments from 5,000 to 6,000 lbs.

In permanent structures, where durability is an essential requirement, and where the floors or beams are for long periods subject to heavy loading, the tension rods will, no doubt, in some places come in continued contact with the air, which may easily enter through cracks in the concrete from below. Such rods will be exposed to corrosion, and the above low unit strains should not be disappointing.

Considerable corrosion could take place in the rods without overstraining the concrete (by a gradual change in the value $\frac{m}{n}$), since the strength of the concrete will have increased with age.

While an increasing, constant deflection will give notice of the deterioration going on, yet there will never be great immediate danger. With respect to more temporary floors and beams, where great strength at least cost is wanted, and great durability is not essential; also with respect to strongly constructed floors, which carry extreme loads only for short spaces of time or accidentally, the table shows an interesting fact. Evidently it would be more economical to insert an additional set of rods for compression near the top of the beam and neglect the resistance of the concrete both for tension and compression. Hardened steel rods, when imbedded in concrete, would stand much greater strains than ordinary steel in tension. Consequently, the capacity could be more than doubled by adding an amount of steel for compression equal to that noted for tension.

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PLUMBING REFORM.*

The object of plumbing, as the word is here used, is the speedy removal of various well-known wastes from houses and other buildings. Their removal is demanded by health and convenience, although in the minds of most people the order is reversed. As a matter of convenience, no one is greatly concerned about the method of removal so long as it is speedy, complete and reasonably cheap. The same might be said from the health viewpoint, were it not for the belief that the exit for the wastes may become an inlet for harmful gases and, as many still think, for various disease germs. Extremists even go so far as to speak of defective plumbing as "a breeding place for all manner of disease germs."

The early alarms over so-called sewer gas, combined with the later fears that arose with the adoption of the germ theory of disease and its relations to house sewage, led to the development of many and diverse traps and a forest of vent and back vent pipes that might well have been the despair of all sane men except plumbers, and which were a source of trouble and grave doubts to the most sensible and honest of that craft.

Many cities and towns, including some of which one would least expect it, are still enforcing or trying to enforce plumbing ordinances drawn in the days when "sewer gas," trap siphonage and "breeding places for disease germs" were still the nightmare of most persons who pretended to be posted in household sanitation. But fortunately for the public health and the private pocketbook a respectably large and a constantly growing number of communities and individuals now realize that a plumbing system greatly simplified as to traps and back vents lessens rather than increases the dangers, both imaginary and real, of house plumbing, besides effecting economies which make possible better material and workmanship for the really essential parts of the plumbing system. Ventilation is still thought well of; in fact, so well that main or running traps are being omitted on house drains and thus the house and the street sewer, as well as the house piping, are being ventilated through soil pipes and their extension to and through house roofs.

Among the reasons not already suggested, for these changes in opinion and practice is the growing acceptance of evidence that disease germs are rarely disseminated through the air of sewers and house plumbing systems; that the air in soil and waste pipes, as a rule, is as bad as or worse than that in sewers; that if only ample ventilation of both the house piping system and the public sewerage system can be afforded by omitting main traps and ventilating through the soil pipes and their extensions, there will be little foul air in sewers, and particularly in well constructed and operated modern sewers; and that through air currents and otherwise back venting pipes are liable to aid more than retard the loss of water seals in traps.

The modern art and science of plumbing makes for simplicity, solidity, accessibility, good material and workmanship, and the fewest possible joints. The best plumbing and sewerage together aim to remove all wastes before offensive decomposition can begin, to reduce to a minimum the number and size of places for the deposit of organic matter and to still further reduce such deposits as do occur by flushing and cleaning, and finally to provide such ample ventilation as will prevent the accumulation of foul odors in public and private sewers and in house plumbing systems.

I have not written of the details of plumbing work and fixtures because they are generally well understood by the best sanitarians and plumbers. The underlying principles of modern plumbing are also pretty generally understood by the most progressive sanitarians and plumbers, but unfortunately many local boards of health are still composed of or controlled by men of the old school, who gained their ideas of plumbing and the other older branches of sanitary work when filth and vile odors were supposed to be the sources of disease and air the chief means for its spread. We now realize, or are beginning to realize that the individual is the source of communicable diseases and that such diseases must be suppressed at their source. The day will come when comparatively little disease-infected waste matter will find its way into the sewers without first having been disinfected and when all our sewage wastes will either be purified or else discharged into bodies of water where they can do no harm—in either case being conveyed from the plumbing fixture to the point of treatment or other disposal so expeditiously and perfectly as to subject no one to risk.

*An editorial by M. N. Baker, Associate Editor Engineering News, published in the "American Journal of Public Hygiene" for March.

A NEW TRANSATLANTIC CABLE is to be built by the Commercial Cable Co., which already has four cables to Europe, the last laid in 1900. Bids for the manufacture and laying are already under consideration.

MAXIMUM MOMENTS AND COST PER LIN. FT. OF REINFORCED CONCRETE BEAMS AND FLOOR-SLABS OF RECTANGULAR SECTION, 1 FT. WIDE.

m/n	f (c = 100)	Moments and cost per ft.	Distance center of rod to top of beam in inches.* 2″	3″	4″	5″	6″	8″	10″	12′	15″	18″	22″	26″	30″
0.1	24,000 pounds per sq. in	Moments, ft. lbs	35	31	144	223	320	566	882	1,270	1,990	2,930	4,270	6,000	7,950
		Concrete, cents	12	15	18	21	24	30	36	42	51	60	72	84	90
		Steel, cents	.09	.14	.19	.24	.28	.36	.46	.55	.64	.85	1.00	1.18	1.37
		Total, cents	12.1	15.1	18.2	21.3	24.3	30.4	36.5	42.6	51.7	60.9	73.0	85.2	91.4
0.2	12,000 "	Moments, ft. lbs	62	141	253	392	567	1,010	1,570	2,270	3,540	5,100	7,660	10,630	14,170
		Concrete, cents	12	15	18	21	24	30	36	42	51	60	72	84	90
		Steel, cents	.32	.50	.68	.84	1.00	1.34	1.66	2.00	2.50	3.00	3.68	4.32	5.00
		Total, cents	12.3	15.5	18.7	21.9	25.0	31.4	37.7	44.0	53.5	63.0	75.7	88.3	95.0
0.3	8,000 "	Moments, ft. lbs	85	191	340	531	770	1,370	2,130	3,080	4,810	6,900	10,300	14,400	19,200
		Concrete, cents	12	15	18	21	24	30	36	42	51	60	72	84	90
		Steel, cents	.69	1.05	1.38	1.74	2.10	2.79	3.48	4.17	5.19	6.24	7.62	9.00	10.38
		Total, cents	12.7	16.1	19.4	22.8	26.1	32.8	39.5	46.2	56.2	66.3	79.6	93.0	100.4
0.4	6,000 "	Moments, ft. lbs	103	233	411	646	934	1,660	2,590	3,710	5,810	8 380	12,500	17,520	23,280
		Concrete, cents	12	15	18	21	24	30	36	42	51	60	72	84	90
		Steel, cents	1.12	1.72	2.28	2.84	3.44	4.60	5.72	6.84	8.56	10.28	12.56	14.92	17.20
		Total, cents	13.1	16.7	20.3	23.9	27.5	34.6	41.7	48.9	59.6	70.3	84.6	98.9	107.2
0.5	4,800 "	Moments, ft. lbs	119	267	472	742	1,070	1,900	2,960	4,270	6,670	9,600	14,330	20,040	26,670
		Concrete, cents	12	15	18	21	24	30	36	42	51	60	72	84	90
		Steel, cents	1.65	2.50	3.30	4.15	5.05	6.70	8.35	10.00	12.50	15.00	18.35	21.65	25.00
		Total, cents	13.7	17.5	21.3	25.2	29.1	36.7	44.4	52.0	63.5	75.0	90.4	105.7	115.0
0.6	4,000 "	Moments, ft. lbs	131	294	525	819	1,180	2,100	3,280	4,720	7,380	10.630	15,900	22,200	29,530
		Concrete, cents	12	15	18	21	24	30	36	42	51	60	72	84	90
		Steel, cents	2.22	3.36	4.50	5.58	6.78	9.00	11.22	13.50	16.92	20.22	24.98	29.28	33.78
		Total, cents	14.2	18.4	22.5	26.7	30.9	39.0	47.2	55.5	67.9	80.2	97.0	113.3	123.8

* For total depth add 2 ins.

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The Fifty-eighth Congress finally expired without enacting any legislation regarding the Panama Canal. A dead-lock occurred between the House and the Senate over the clause in the House bill abolishing the Panama Canal Commission, the Senate insisting that the Commission should be retained. As neither side would yield, the bill failed to pass.

This failure of legislation does not affect at all the canal work, or the authority of the President to control it. The legislation particularly desired was not in connection with the canal work, but in connection with the civil government of the Canal Zone. The act of April 28, 1904, definitely vested in the President and his appointees power to carry on the military, civil and judicial government of the Canal Zone "until the expiration of the Fifty-eighth Congress." As Congress has failed to make other provision for the government of the Zone, it will certainly be held that the President's authority continues, inasmuch as the responsibility would fall anyway on the Executive Department in the absence of any legislation by Congress.

We said in our issue of Jan. 26 that the abolition of the Commission would seem undesirable from every point of view; and that it was difficult to see how the President could need any fuller authority to control the Commission and its employees, or to direct the work of constructing the canal than he already possesses. We are of the same opinion still and find no cause for regret therefore, in the failure of the House bill to become a law.

The responsibility is now left with the President of making such alterations in the organization of the Commission or in its methods of work as shall permanently remove any causes of complaint or public criticism. It is to be hoped that this may be done and that the work at Panama may be placed on such a basis that when the new Congress assembles next fall, the abolition of the Canal Commission will not even be suggested.

The bill granting New York City the power to obtain a great new water supply for itself from the elevated and sparsely populated watersheds in the southern part of the Catskill Mountains is now before the New York Legislature, and ought unquestionably to be at once put on its passage and made a law without a dissenting vote.

That the city must have this supply, and that every day's delay in securing it means an added day of peril from water famine, should a period of drought appear, is a fact attested by the most competent experts. Yet instead of promptly enacting the bill, the legislators at Albany appear to be giving ear to various objectors, who urge that the local interests ought to be considered of the communities in these watersheds which aspire to metropolitan greatness, and that New York ought to go at once to the Adirondacks for its supply of water.

It is an old story, this talk of an Adirondack water supply for New York City, and so much attention is being given to it just now in the public prints that a word on the subject may be appropriate in this place:

To the popular mind, the idea of bringing a water supply to the great metropolis from the Adirondack wilderness has great attractions. New Yorkers are familiar with the lakes and streams of the Adirondacks, and to bring the water flowing from these uninhabited forests and mountains and make it available for consumption in New York City naturally appears to the lay mind as an ideal project.

But great enterprises can never be fairly judged on a purely ideal basis. The engineer accustomed to deal with these matters from a practical standpoint knows that if it were possible to bring the water of many of the Adirondack streams direct to New York City and deliver it there in exactly the same condition as when it started, it would be indignantly rejected by the public on account of the color it had acquired from the vegetable matter in the swamps where it has its source.

Of course, if it were seriously proposed to bring Adirondack water to New York City, it would doubtless be possible to bleach and purify the water in storage reservoirs at its source; but it is the bringing the water to New York City that presents the difficulty. From the lowest point on the upper Hudson, where the water might be taken to New York, is a distance of nearly 200 miles; and as the Burr-Hering-Freeman Commission on the New York water supply said in its report a year ago: "The high cost of the project to convey this water by aqueduct to New York City prohibits its execution."

We need not go into details to prove this. Even the layman can understand that if an estimated expenditure of $111,478,000 is involved in bringing a flow of five hundred million gallons daily from the Catskill watershed by gravity to New York City, a distance of 60 to 70 miles, a vastly larger sum, quite beyond the reasonable financial ability of the city to provide, would be involved in bringing an equal supply from a source nearly three times as far away.

Doubtless at some future day New York City will use Adirondack water, but it will not build an aqueduct all the way from the Adirondacks. Instead, the water will be taken from the Hudson River above tide-water, after it has flowed in its natural channels for a hundred miles or more, and received pollution from the sewage of Albany and Troy and other populous cities of the Hudson Valley. This water will have to be purified by artificial filtration, and elevated by pumping engines to a point high enough to furnish the necessary pressure to the city.

If the city chose to do so, it might adopt this plan of securing an additional water supply at the present time, instead of developing the Catskill watersheds. Would New York prefer an Adirondack water supply of this sort? Unless we greatly mistake public opinion, there is no doubt how this question would be answered. The opinion of engineers agrees with that of laymen that a gravity supply of water from an unpolluted source, so long as it can be secured at a reasonable outlay, is much to be preferred to a supply of polluted water which must be filtered and pumped to make it available. New York City is so fortunate as to have within reach an upland drainage area well-nigh ideal for the collection of a supply of potable water. It cannot be possible that the legislature will fail to give her all necessary authority to supply herself from this source.

In connection with the bill for New York's new water supply, much has been heard of a proposal to create a State Water Commission, to have jurisdiction over the natural waters of the State, and prevent conflicts between rival appropriators of water. This proposal has little relation to New York City's situation, for no other large city of the State is so located as to be able to utilize the Catskill drainage areas for its water supply.

That a properly organized State Water Commission might be of large public service in bringing about the best utilization of the State's water supply resources admits of little doubt. Such a commission should have power to deal also with stream pollution abuses and with such matters as water storage and flood protection. It could control matters of water supply on the broad principle of the greatest good to the greatest number, and could enable a city desiring to obtain water for its own consumption to proceed directly, with due compensation to private owners, without the necessity of an appeal to the legislature.

If, then, the legislature decides to create a State Water Commission, properly constituted for the work laid upon it, there should be no objection; but the move for such a commission should not be permitted to defeat or delay favorable action on the New York water supply bill.

A quarter-century ago the belief was universally held by sanitarians that sewer-gas was a source of a great amount of disease and a standing menace to health. As a result of this belief, modern systems of plumbing are encumbered with a considerable amount of complications that are probably, in the long run, more of an injury than a benefit. Among these is the disconnecting trap for cutting off the sewer system from the pipes inside the house. Such traps still continue in general use, largely because the public has not unlearned the lessons taught by sanitarians of the past generation. Moreover, when once high authority has declared a certain thing to be an absolute necessity to the safety of health, and it has been universally adopted, it requires considerable courage for any one to assume the responsibility for discarding the device. Be he sanitarian or physician, he well knows that whatever cases of disease may occur there during the next ten years will be surely ascribed to the omission of that time-honored safeguard, and the responsibility for disease and death will be laid on his shoulders.

This is one of the reasons why the report by Mr. Allen Hazen on the sewers of Winnipeg, printed in this issue, is especially noteworthy. A perusal of this report will show that Mr. Hazen recommends that the Winnipeg sewers be ventilated through the house soil pipes, a proposal which even at this day will doubtless shock some who pose as sanitary experts.

The excellent summary of the work in progress by the U. S. Government for the improvement of the navigation of the Mississippi River from St. Louis to Cairo, which is given in this issue, will be read with interest, we are sure, by the rapidly increasing number of engineers who are keeping posted regarding the art of river regulation. There can be little doubt that this is a branch of engineering in which a vast amount of work is to be done in this country, notwithstanding the fact that almost nothing has been done up to the present time. With the rapid increase in land values, it will soon become too costly to permit floods and erosion to lay waste every year the many thousand acres which are now sacrificed to our uncontrolled water courses; and a demand will grow up here for the same sort of work on river regulation that has become common in engineering practice in Europe.

The paper referred to is notable for another reason. It will be a surprise to many engineers, doubtless, to learn that the work of the famous dredges on the Mississippi is regarded as merely a temporary expedient, and that in a few years, when the permanent bank protection and channel

contraction works now under way are completed, there will be a continuous low water depth of at least 8 ft. all the way from St. Louis to Cairo.

Another paper in the present issue gives an example of the class of work in river regulation in this country which is now under contemplation and which must ere long be put under actual construction. We refer to the report of an engineering commission on the reclamation of a great tract of land along the lower courses of the Sacramento and San Joaquin Rivers in California. This enterprise contemplates the protection from floods of a region some 1,700 sq. miles in extent at an expenditure of nearly twenty-five million dollars.

The report of the commission of engineers is noteworthy for the discussion which it presents of various schemes which have been proposed for the improvement of the river and the reasons which are assigned for their rejection. It will be seen that in the plan which the Commission finally recommends, chief reliance is placed on the construction of levees to confine the river to its main channel.

It may be said with little fear of contradiction that this is the method of river regulation which will be adopted in the great majority of cases as a result of careful engineering investigation of the problem. Flood control by reservoir construction or by the creation of by-pass channels may have applications in certain exceptional places; but in the great majority of cases where flood protection is demanded, these systems are wholly inapplicable.

SOME RECENT SPECIFICATIONS FOR RAILROAD WORK THAT ARE SPECIFIC AND FAIR.

So many ambiguous or one-sided contracts come to this office that we read with great pleasure a contract that is both clear as to its specific clauses and just as to its general clauses. Contracts for railroad work have, in the past, been noted for their one-sidedness; and, while recognizing the motives that have led railroad engineers to attempt to tie the contractor's hands, we feel that the time has come to treat the contractor as a business man rather than as a boy bound out to work. In the days when surety companies did not exist, and when personal bonds were usually found to be worthless, contracts were drawn with one point always in mind, namely, to prevent a contractor from skimming the cream off his work and absconding. Another point was kept prominently in mind, namely, the prevention of lawsuits arising from claims for extras or delays caused by failure to get right of way, etc. With these ends in view, engineers and lawyers combined their wits in the drawing up of contracts to make the engineer's authority supreme and final in the interpretation of clauses purposely left ambiguous so as to cover all possible contingencies. Whether the times and the men justified such contracts we will not discuss, but we believe that they are not justified under present conditions, that they do not prevent lawsuits, but foster them, and that they do not scare out rascality, but encourage it.

From the letters that we have received and are receiving from engineers, we know that this feeling is not confined to a few whom some in derision would term "theorists" or sentimentalists, but that we voice the beliefs of many an engineer whose experience has been long enough to teach him that the old forms of contracts are breeders of little troubles, which develop into the bigger troubles known as suits at law.

We have at hand the contract and specifications for a long piece of double-track work on the Illinois Central R. R. This contract has been written in a spirit of fairness throughout, and contains general and specific clauses of decided interest. We shall quote a number of these clauses, with the comments of their author:

2. A deposit of cash to the amount of $1,000 shall be made by the contractor with the railroad company upon the execution of this contract. If the contractor begins the work with an adequate force and equipment at the time specified in Article 1 of this contract, and prosecutes the same with diligence until the amount of the reserved percentage, based upon the estimates as provided by Article 8 hereof, equals the amount of the deposit, such deposit shall be returned to the contractor. Should the contractor fail to begin the work with an adequate force and equipment at the time specified, or to prosecute the same with diligence to the extent aforesaid, the railroad company shall have the right, after having given ten days notice of its intention of so doing, to call for new bids and make a new contract for doing the work without unnecessary delay, and in case it should so do, the contractor hereby binds himself to repay to the railroad company the resulting damage or loss on account of such delay, and in order to avoid any dispute or litigation as to the amount of such damage or loss, it is hereby estimated that the damage will be $75 per day for each day that elapses between the date set for the beginning of the work in Article 1 and the date set for the beginning of the work under the new contract as relet, the aforesaid sum per day being mutually agreed upon as reasonable liquidated damages. The railroad company may apply the said deposit, as far as it goes, to the payment of the resulting damage or loss aforesaid, and the railroad company is hereby authorized to use said deposit for such purpose.

"In the writer's experience he has found it necessary that there should be some hold upon the contractor such as this clause gives, as in the great majority of cases the completion of a piece of work in the specified time largely depends on the way in which it is planted; for, if the contractor does not start the work in the proper manner, it is a rare thing to get him to complete it on time."

4. The railroad company may, at its option, make any alterations by adding to or omitting or deviating from the plans, drawings and specifications, or any of them, which it may deem proper, or may relocate in whole or in part its line upon which the work is to be done, without impairing the validity of this contract; but such alterations or relocations before becoming effective shall be specified in writing to the contractor by the engineer. Alterations or relocations so made shall not affect the prices to be paid for the work as agreed upon herein, provided such alterations or relocations do not cause an increase or decrease within the sphere of the alteration or relocation of the work, exceeding 20% of the number of cubic yards, or an increase or decrease within the sphere of the alteration or relocation of the work exceeding 20% in the average length of haul, the basis of computation to be in all cases the estimates of the engineer. In case such alteration or relocation increases or decreases the said number of cubic yards or the said average length of haul more than the last named percentages respectively, an increase or decrease in the prices agreed upon herein shall be arranged between the chief engineer of construction and the contractor, provided they can agree as to the amount of said increase or decrease in said prices. Failing in agreement, the railroad company shall have the privilege, should it so elect, of calling for new bids and reletting the changed portion of the work, under which circumstances the contractor will be relieved of responsibility for such changed portion, but this contract shall remain in force for the balance of the work.

"This changing of work, as you well know, is one of the most difficult features of construction to be handled. This clause has been found to work quite satisfactorily, as the ability on the part of either the contractor or railroad company to throw up a certain piece of work that has been changed in case an agreement as to the changed price cannot be arrived at, is a sufficient spur, in the long run, to bring either party to terms, and at the same time will act as a safeguard in case either party is inclined to be totally unreasonable."

12. It is expressly agreed that no compensation for extra work, and no compensation additional to the compensation hereinbefore stipulated, shall be paid to the contractor, unless such extra work shall have been ordered in writing and such additional compensation shall have been agreed to in writing by the engineer. All bills for extra work must be delivered to the engineer immediately in charge of the work before the fifth day of the month next succeeding the month in which the work is done. In case the contractor should delay presenting bill for extra work until the fifteenth day of the month next succeeding the month in which the work is done, only the actual cost of the labor and materials used in the work shall be paid by the railroad company, no additional percentage being allowed to cover the cost of supervision, use of tools and plant. It is a condition precedent to recovery therefor, that all bills for extra work must be delivered to the engineer immediately in charge of the work before the last day of the second month succeeding the month in which the work is done.

"Delay in presenting force account bills promptly is a fruitful source of discord. This delay gives an unprincipled contractor an opportunity of presenting bills after the time has gone when a proper check can be put upon them. It is frequently due to the neglect of business on the part of the engineer in charge; but, with such a spur behind him, the contractor will in all probability see that the engineer in charge handles the work in a businesslike manner."

13. If at any time before the completion of the work, the contractor shall make default in the performance of this contract, or of any of the stipulations or terms hereof, or if in the opinion of the chief engineer of construction the work shall not proceed with sufficient rapidity for the proper performance of the contract within the specified period of time, the railroad company may, at its election, cause a written notice to be served on the contractor, calling attention therein to the default, neglect or delay to which exception is taken, and requiring the contractor to increase the amount of work being done to such a rate per week as will enable him to complete the work within the specified time, and, should the contractor fail to so prosecute the work, it shall be lawful for the railroad company, upon the expiration of two weeks from the date such notice was given, to declare this contract terminated, and on such declaration being made in writing by the railroad company, or its authorized officer or agent, to the contractor, or to the representative of the contractor in charge of the work, the right of the contractor to do any further work under this contract shall immediately cease and determine, and the railroad company may retain the before-mentioned reserved percentage, together with any unfinished estimates or moneys due the contractor, until the completion of the work, and may reimburse itself therefrom for any damages which the railroad company may sustain, by reason of the non-performance by the contractor of this contract. In estimating such damages are to be considered the salaries and expenses of the engineers and any employes of the railroad company engaged in the work, any additional expenses incurred in maintenance and operation, by the railroad company, the delay of the railroad company in obtaining the use of the work, and any legal damages that may be shown as arising from such non-performance; or, as an alternative to such declaration, the railroad company shall, at its election, have the right to cause such portions of the work as the engineer may designate, to be performed by the agents or employes of the railroad company; or, as an additional alternative thereto, at its election the railroad company may require the contractor to employ such additional men, carts, teams, machines, etc., as the railroad company may be able to procure, in either of which cases the railroad company shall have the right to retain from the amount of the estimates payable to the contractor, as provided in Article 8, an amount sufficient to defray the cost and expenses of the measures so taken. In all cases the railroad company shall be entitled to reimbursement by the contractor to the full extent of the damge or loss arising to the railroad company by default of the contractor under this contract. It is of the essence of this contract that the rate of progress of the work shall be such as to enable the contractor to complete it within the period of time specified in Article 1, and that it shall be completed on the date therein specified.

"Experience of a number of years in construction work has convinced the writer that such a clause as this is a necessity. An attempt has been made to draw this clause in such a way that it will stand in the courts, and, at the same time, will not work an undue hardship on the contractor."

18. It is agreed that the railroad company shall have the right at any time to stop the work, either temporarily or permanently, or, first temporarily, then by further notice permanently, by giving the contractor not less than ten days' notice in writing of the date on which the work shall be stopped. Where the proposed stop is stated in such notice to be temporary, the work shall be resumed by the contractor within ten days after the date fixed in a written notice by the railroad company to the contractor to resume the work. In case the work is directed to be stopped permanently, the railroad company shall not be liable for any damages on account of the work being stopped, or for any work done after the date fixed in such notice for stopping the work, but will furnish free return transportation corresponding with any free transportation that was issued to enable the contractor to undertake the work. In case the work is directed to be stopped temporarily, the railroad company shall not be liable for any damages on account of the work being stopped, or for any work done between the date upon which the work is required by the said notice to be stopped and the time when the work shall be resumed under this contract, or such stop is made permanent as herein provided. It will, however, in lieu of such liability, pay the contractor for actual loss of time during such temporary stop, of men on monthly pay, and teams (provided it is not, in the judgment of the engineer, practicable to move these men and teams to other points at which they can be engaged in work), at the rate of $1 per day for each man, and $3 per day for each team of two horses, between the date on which notice is given for the work to be stopped and the date on which notice is given for the work to be started, such payment to be binding upon the contractor as a settlement in full for all claims that may arise on account of time lost. Further notice that the stop shall be made permanent shall operate from the time of receipt thereof, the same as an original notice of permanent stop.

"It has been found to be advisable to have a definite understanding as to exactly what price will be paid to the contractor in case his men are temporarily laid off under orders from the engineer, and that price is put at a sum that will barely suffice to cover the actual cost that the contractor will be under, the intention being that, while not suffering a serious loss, he has a sufficient spur to keep him continually active to get his forces to work after a temporary stoppage."

21. The contractor hereby agrees to hold the railroad company free and harmless from all liability, loss, damage, costs and expenses growing out of, or arising from, damage or injury to property, or death, damage or injury to persons which shall be caused wholly or in part by the negligence of agent or employes of the contractor, or by the negligence of sub-contractors, or by the negligence of agents or employes of sub-contractors, or by the neglect or failure of the contractor or of sub-contractors, or of agents or employes of the contractor, or of agents or employes of sub-contractors, to observe or perform any of the promises, requirements or terms of this contract; and if suit shall be brought against the railroad company to recover for any liability, death, loss, damage or injury described in Article 20, or in this article, the contractor agrees to defend such suit without cost to the railroad company, and to pay any judgment that may be recovered therein, and to save the railroad company free and harmless from any loss, costs, attorney's fees, damages or expenses thereby.

22. The railroad company, or any railroad company protected by Articles 20 and 21, shall have the right, in its discretion, to compromise or settle any claims against it, whether alone or jointly with other parties, arising on account of any liability, death, damage, loss or injury described in either of the said Articles, and such compromise or settlements shall be binding on the contractor.

The two clauses, while seemingly stringent,

cover no risk that the contractor is not able to protect himself against by insurance.

25. The railroad company will furnish such work train service as may be necessary for the contractor in the unloading of his plant, and re-loading of the same upon completion of the work, and in the cutting in and out of his steam shovels and such other work of a similar character as may be necessary in the judgment of the engineer. For such work train service the railroad company will make no charge for engines or cars furnished, but the contractor will pay the railroad company at the rate of $15 per day for the same to cover the wages of train and engine crew, and other expenses exclusive of fuel, which is to be furnished by the contractor.

26. The railroad company will furnish the contractor with the necessary second-hand rail and splices for use during construction. The contractor will be charged for the same at the rate of $24 per ton for the rail and $0.50 per pair for the splices. Upon completion of the work the railroad company will pay the contractor at the same rates for all rail and splices returned to it in as good condition as when delivered to the contractor, ordinary wear and tear excepted. The contractor will pay the railroad company for the use of the rail and splices at the rate of 1% of its value per month from the date of its receipt until the date of its return, loaded on carts at ——.

"The clauses aim to give train service and rails to the contractor at the lowest possible cost, and at the same time have sufficient cost placed upon him to give a constant incentive on his part to handle the work in a businesslike manner. The aim has been to evolve a contract that, without the ordinary clauses giving undue powers to the engineer, will be perfectly satisfactory to both the contractor and the engineer, and at the same time will give the engineer sufficient control of his work to enable him to see that it is promptly and efficiently carried on, and will give also a contract that will stand in court."

"The articles that have been appearing in Engineering News for some time, bearing upon the subject of specifications, have been of great assistance. Since these specifications have been in use, we have had no controversies with contractors that have not proved to be easily adjusted."

LETTERS TO THE EDITOR.

How Should the Load of a Culvert Under a High Embankment Be Computed?

Sir: There seems to be a diversity of opinion among authorities as to the load of earth to be considered in determining the thickness of covers for box culverts under high embankments. One tells us to use the weight of all of the material directly over the culvert, while another advises the use of but a portion of this load and no live load. One says that under high embankments especial care must be taken with the foundations lest the culvert should be crushed into the earth beneath, while another says that were the full weight of the material over the culvert to come upon it, many culverts now standing would be crushed to smithereens.

Will you kindly submit this matter for discussion in your paper, and also the question of the distribution of the live load on top of such an embankment.

Very truly yours, Geo. R. Winslow.

20 Pemberton Square, Boston, Mass., Mar. 1, 1905.

Concerning the Design of the Blackwell's Island Bridge.

Sir: Allow me to put a question concerning the Blackwell's Island Bridge, referring to your editorial comment upon the advisability of a constrained cantilever instead of a cantilever of the ordinary type.

How does this constrained cantilever compare with an ordinary continuous truss?

It seems strange to cut the truss at that point where the bending moment in the ordinary continuous truss would be maximum, as is done in the case of the constrained cantilever type, while in the ordinary cantilever truss the points chosen to cut the continuity are those where the bending moment would be approximately zero for uniformly distributed loads. Is this fact not of more importance than the advantage of having a truss less statically indeterminate than the ordinary continuous truss, when it is not made entirely statically determinate; and is not therefore the continuous truss preferable to a constrained cantilever truss, although this gives better means to provide for expansion by temperature changes?

Yours truly, R. Reimann.

Cumberland, Md., Feb. 25, 1905.

Drainage and Track Construction at Belmont Park, Queens, L. I.

Sir: In reference to your article in the Feb. 23, 1905, issue of Engineering News, on the subject of Belmont Park Racetrack, the writer would like to call your attention to the fact that the "drainage" referred to in the paper as a minor item, was in reality one of the important divisions of the work, and its cost amounted to a fair percentage of the whole sum total. It is true that Long Island soil is very porous and carries water away freely, but the drainage system here employed is provided to meet every emergency, and is a system as nearly perfect in its plan as any ever installed on a racetrack. It is safe to say that even after the heaviest storm the tracks will be about the dryest places on the grounds.

There are altogether three entirely separate lines of drains. One (4,100 ft. long) extends throughout the whole course of the backstretch of the main track, beginning about 900 ft. around the west turn from the P. C., and emptying into the ravine of the one-mile track infield. This drainage finally passes through the culvert under the eastern end of the ⅞-mile straightaway. Lateral branches about 300 ft. apart, extending from the outside of the main track and steeplechase, connect with this main, thereby draining the entire territory of the track. The second line extends through almost the entire length of the homestretch and ⅞-mile chute, is 3,500 ft. long, and is connected with lateral branches from 200 to 300 ft. apart. This empties into the lower portion of the same ravine, and the drainage from the whole track territory meets and combines at this point, excepting what of the former has not soaked away in its course from the upper to the lower end of the ravine. The third line is another independent line, receiving the drainage from the building leaders and the main approach driveways. This runs down the main approach to the Long Island R. R. drain and, including the latter, is about 3,000 ft. long. It empties into a ravine at the far southeastern part of the property. Besides the leader drains, even the concrete floors of the grandstand and fieldstand are drained, so that one can judge the vast territory, altogether, that is provided for. In all there are about 28,000 ft. of drain pipe varying from 4 ins. to 30 ins. in diameter. From this description one can judge that it would be difficult to plan a drainage system of more completeness than this, and that as long as the drains are kept clean, Belmont Park will serve wet weather racing with almost the same comforts as dry weather.

I would like to add that, contrary to your statement, there was no screened topsoil used on the track for a surface dressing. It has been found necessary to screen the topsoil for a great many tracks, but here the pebbles and foreign matter not removed by harrowing and raking were picked up by hand. Yours very truly,

Richard Schermerhorn, Jr.

29 Broadway, New York City, Feb. 27, 1905.

Right-Angled Triangles with Sides of Integral Ratios.

Sir: If to a square A, whose side is of unit length, we add three equal squares B (see sketch herewith), the area becomes $2^2 = 4$. Add, further, five squares C, seven squares D and nine squares E, and the area increases step by step to $3^2 = 9$, $4^2 = 16$, and $5^2 = 25$. The result may be tabulated thus:

A	B	C	D	E
B	B	C	D	E
C	C	C	D	E
D	D	D	D	E
E	E	E	E	E

$$1 = 1^2$$
$$1 + 3 = 4 = 2^2$$
$$4 + 5 = 9 = 3^2$$
$$9 + 7 = 16 = 4^2$$
$$16 + 9 = 25 = 5^2$$

This is shown in order to recall the fact that to write a table of squares we need merely to add together the odd numbers in regular progression, beginning with one. When in the course of the work we come to the squares of odd numbers, 3, 5, 7, 9, 11 and 13, the lines corresponding are:

$$16 + 9 = 25 = 5^2 = 4^2 + 3^2$$
$$8$$
$$144 + 25 = 169 = 13^2 = 12^2 + 5^2$$
$$12$$
$$576 + 49 = 625 = 25^2 = 24^2 + 7^2$$
$$16$$
$$1{,}600 + 81 = 1{,}681 = 41^2 = 40^2 + 9^2$$
$$20$$
$$3{,}600 + 121 = 3{,}721 = 61^2 = 60^2 + 11^2$$
$$24$$
$$7{,}056 + 169 = 7{,}225 = 85^2 = 84^2 + 13^2$$

These equalities show that we can draw right-angled triangles having sides measuring 3, 4 and 5, or 5, 12 and 13, or 7, 24 and 25, or 9, 40 and 41, etc. There is a constant increase of two units in the length of the short side of the triangle, the difference in lengths of the long sides increases constantly by four, as is shown by the differences which are interlined, and the length of the hypotenuse is one unit greater than the length of the long side of the triangle. Upon expressing the relation algebraically, there results an equation

$$(2n + 1)^2 + (2n^2 + 2n)^2 = (2n^2 + 2n + 1)^2$$

in which we can substitute any number, integral or fractional, solve and obtain the lengths of the sides of a right-angled triangle in which the hypotenuse is one unit longer than one of the sides, and in which the three sides are commensurable. The number of combinations possible is infinite, and any given angle can be approximated with mathematical exactness, but for ordinary purposes a table will be found useful which gives the sides of such triangles as can be constructed without the use of inconveniently high figures.

In detailing layouts of one sort or another where other angles than 90° must be used, as, for instance, in the case of special pipe connections or structural details, the angle chosen may usually be varied within considerable limits, and it is desirable to avoid inconvenient fractions. By referring to the accompanying table, which gives the sides of a series of triangles as calculated from the formula, absolutely exact dimensions can be secured by choosing a suitable unit. Whether it be an eighth of an inch, an inch, or a foot, will depend upon the case in hand, but no time or effort need be wasted in solving triangles.

Under the column of the table headed N, appears the number used in the equation to secure the corresponding values for the sides a and b and the hypotenuse c of the triangle. Where fractions were used all terms were reduced to a common denominator, and the numerator appears in the table alone, as the proportion only is desired, not absolute values. In the second column is given the approximate size in degrees of the small angle of the triangle.

The writer has never seen any such table, nor any reference even to the possibility of preparing such a one, and having himself looked into the relation by chance, believes that, if not new, it is at least not in common use, and should therefore be welcome to many engineers and draftsmen. Yours truly,

"Copperhill."

TABLE OF RIGHT TRIANGLES WITH INTEGRAL LENGTHS OF SIDE.

Calculated from formula:

$$(2n + 1)^2 + (2n^2 + 2n)^2 = (2n^2 + 2n + 1)^2$$

n	Small angle of triangle, in degrees (approx.).	Sides of Right-Angled Triangle. a	b	c
57	1	115	6,612	6,613
28	2	57	1,624	1,625
19	3	39	760	761
14	4	29	420	421
11	5	23	264	265
9	6	19	180	181
8	6¼	17	144	145
7	7¾	15	112	113
6	8¾	13	84	85
5½	9½	24	143	145
5	10½	11	60	61
4½	11½	20	99	101
4	12¾	9	40	41
3½	14¼	16	63	65
3¼	15¼	60	221	229
3	16¼	7	24	25
2⅞	17	120	391	409
2¾	17½	52	165	173
2⅔	18	57	176	185
2½	19	12	35	37
2⅓	20	51	140	149
2¼	20½	44	117	125
2⅛	21	135	352	377
2	22⅔	5	12	13
1⅞	23¼	152	345	377
1¾	25	36	77	85
1⅔	26	39	80	89
1⅛	26¼	105	208	233
1½	28	8	15	17
1⅜	29½	95	168	193
1⅓	30½	33	56	65
1⅒	31	180	299	349
1¼	32	56	90	106
1⅛	32¾	85	132	157
1⅛	33½	60	91	109
1⅛	34¼	104	153	185
1⅑	35	228	325	397
1	37	3	4	5
⅑	38¼	368	465	593
⅞	39¾	88	105	137
⅝	41	48	55	73
⅘	42	65	72	97
⅞	42¾	207	224	305
¾	43½	20	21	29
⅗	44¾	119	120	169

The Cost of Concrete Fence Posts.

Sir: For some time the Division of Tests, U. S. Department of Agriculture, has been investigating and collecting data on the subject of the relative merits and economy of reinforced concrete as against wooden fence posts. In Engineering News of Jan. 26 appeared an abstract of a paper by J. A. Mitchell, which, if the information it contains is correct, should settle the matter once and for all in favor of concrete. According to information in possession of this Division sawed wood fence posts can be obtained in few localities in the United States for less than 20 cts. apiece, and in some places they run as high as 40 cts. According to Mr. Mitchell:

Posts can be manufactured at a cost of from 11 cts. to 12½ cts. each, counting cement at $1.50 per barrel, gravel at 40 cts. per yd., metal at 2¼ cts. per lb., and labor at $1.50 per day. Two men will make 100 posts per day, while three good men can make from 175 to 200 per day.

Unfortunately, the original paper is not at present available to us and in your abstract the formula of the mixture, the dimensions of the posts, the amount of reinforcement and the price of sand are not given.* In our own calculations, assuming posts 6 × 6 ins., 6 ft. long, with a ½% reinforcement and a 1:3:5 mixture, we find that a concrete post would cost about 21 cts., exclusive of labor and the cost of lumber used in making the forms. According to our figures a cubic yard of concrete would make 18 posts, and, therefore, to make 100 posts in a day 5½ cu. yds. of material would have to be handled, mixed, filled in the molds with reinforcement and tamped. It is difficult to see how two men could accomplish this task,

*Our abstract stated the proportions as 1 to 3, 1 to 4 and 1 to 5, which with the price of gravel (40 cts.) shows that the posts were composed of cement and gravel; not cement, sand and stone.—Ed. Eng. News.

whether they were good men or otherwise. If the dimensions of the posts are much smaller than 6 × 6 ins. they would not develop the necessary strength and would not compare favorably with wood. Mr. Mitchell states that galvanized metal should be used. This has not been our practice, and as all the evidence we can obtain goes to show that steel embedded in concrete does not rust to any appreciable extent, in our opinion the use of galvanized metal can be dispensed with.

So many letters reach us asking for information about reinforced concrete fence posts that we are endeavoring to get at the facts.

Respectfully,

Allerton S. Cushman,

Assistant Chief, Division of Tests, Bureau of Chemistry, U. S. Dept. of Agriculture.

Washington, D. C., Feb. 10, 1905.

We referred the above inquiry to Mr. Mitchell, the author of the paper, who replies as follows:

Sir: In reply to your letter of Feb. 18 I send you circular illustrating the post. Replying to the inquiry of your correspondent, I will say that a post of the dimensions mentioned, 6 × 6 ins. and 6 ft. long, contains 2,592 cu. ins., while my post (which is tapered) only contains 1,008 cu. ins.; hence the great difference in price of construction. When I mention gravel I include the sand also. One cubic yard of concrete will make 40 posts, as I make them. My post is strong enough for fence purposes as a test has proved. When I say "galvanized" metal I know what I am talking about. There is a wide difference between a concrete fence post and a bridge or building of concrete. The corrosion of plain iron or steel sets in before the concrete has attained its strength, and in a post where the concrete is only about ¼-in. thick on top of the metal it is liable to corrode. This I positively know to be the fact. In bridge or building construction where there is a larger body of concrete covering the metal there is no danger, or not so much danger of weakening the body of concrete by corrosion of metal. It is a mistake to say that plain iron or steel does not rust when embedded in concrete.

J. A. Mitchell.

Goshen, Ind., Feb. 20, 1905.

Empirical Formulas for Crown Thickness of Masonry Arch Bridges.

Sir: I have failed to note any response to your suggestion in your issue of Nov. 24, 1904 (p. 487), that the limits of application of formulas for crown thickness of masonry arches be specified by their authors. I wish to present more conclusive proof that these formulas are not consistent, and that Low's formula especially, which was first presented in Engineering News of Sept. 15, 1904, is inconsistent.

VARIOUS EMPIRICAL FORMULAS FOR CROWN THICKNESS OF MASONRY ARCHES AND THICKNESS OF SOME ACTUAL ARCHES.

For Rise of 20 ft. and Fill of 2 ft. over crown.

The formulas are: Perronet $C = 1\frac{1}{5} + \frac{1}{20} S$.
Rankine $C = \sqrt{0.12r}$.
Trautwine $C = \frac{1}{4}\sqrt{r + \frac{1}{2}S} + 0.2$.
Low $C = \frac{1}{8}\sqrt{(S - R)\ 10 + 2F}$.

Where C = crown thickness, in feet.
S = span, in feet.
R = rise, taken as 20 ft. in diagram.
F = fill over crown, taken as 2 ft. in diagram.
r = radius of intrados.

In the accompanying diagram are the loci for Perronet's, Rankine's, Trautwine's and Low's formulas, the crown thickness being plotted vertically and the spans horizontally. The rise is assumed constant at 20 ft., and the fill over crown (which occurs in Low's formula only) is assumed to be 2 ft. Note that the curves with the exception of Rankine's are right lines or curves convex upwards, and that Rankine's is concave upwards for the shorter spans only and rapidly approaches a right line for the longer spans.

Let us assume that for an earth filled arch, with all concentrated loads eliminated, an arch rib may be designed that will be absolutely free from bending moments, that is an ideal linear rib. In such an arch, if we double the span without changing the rise, we double the load and double the flatness of the arch, hence quadruple the thrust. And generally, in such an arch, the thrust would vary as the square of the span, if the additional load due to increased crown thickness be neglected; or, taking this latter load into account, the thrust would vary as some power of the span higher than the second. In such an arch the crown thickness should vary as the thrust.

A formula in which the crown thickness is expressed as a function of the square of the span, or as some higher power of the span, would be concave upwards, and of the general form shown by the curve plotted on the diagram as $C = aS^2 + b$. The linear rib gives the most efficient crown section, hence all formulas for circular segments or other curves, and allowing for live loads, must give values lying above a curve of the general form above. Concentrated loadings, and the use of arbitrary curves for the arch instead of the linear rib, will of course materially modify the above relation between thrust and span as well as between crown thickness and thrust. But as the span increases, with rise remaining constant, the concentrated loads become of less relative importance, and even the circular segment approaches the linear rib.

It is evident that, contrary to the above deductions, every one of the four formulas given, will give values for long spans which will be less than the values given by the formula for linear rib. All of the curves shown will at some point intersect a curve concave upwards, instead of lying above that curve, no matter what may be the value of the constants in the general formula. Hence the formulas are erroneous for long spans.

It is possible, however, that the erroneous values might lie wholly outside of present or prospective applications in actual construction. I have therefore plotted on the diagram as small circles, the crown thickness of several spans taken from tables in Howe's "Treatise on Arches," selecting those examples in which the rise varies from 17 ft. 6 ins. to 22 ft. 6 ins., as being approximately 20 ft. in rise. I have also shown, by miniature squares, the values taken for similar spans from Low's table in Engineering News of Sept. 15, 1904. It is apparent that almost any formula could be made to pass through an average of the points shown, and I wish to suggest that a formula might as easily have been selected that would have been consistent for long and short spans and would still have fulfilled empirical requirements. Low's formula in particular seems to have been selected with no regard for any field outside of a narrow limit, and not to have any special advantages even for that narrow limit. Note, for example, that for an arch with rise greater than span the crown thickness passes through zero and becomes an imaginary quantity. Why such a formula, when one in which crown thickness varies as the square of the span would give as accurate results?

In Low's formula, moreover, the fill over crown receives erroneous consideration. According to the formula, an increase in depth of filling has a greater effect on short spans, and a rapidly decreasing effect on longer spans, whereas, in reality, increased fill over crown affects long flat spans much more seriously than short spans.

For fear your readers may think that I am criticising without offering a remedy, I would explain that I have derived a crown formula for a particular type of concrete arch, with which I have had sufficient experience to enable me to determine the constants, but that my experience with masonry arches in general has been too limited to enable me to make the application to stone arches. Investigation in a limited field has, however, brought to my attention the defects in the usual formulas as noted above.

Very truly yours,

Daniel B. Luten,

Prest., National Bridge Co.

Indianapolis, Ind., Feb. 15, 1905.

Standards of Weights and Measures in Great Britain.

Sir: In an editorial published in your issue of Feb. 23, relative to the metric system, you make the following statement:

That Great Britain badly needs to modernize her system of weights and measures will be conceded by both the advocates and opponents of the Metric System.

I cannot quite agree with you on this point. Great Britain has done a great deal more to "modernize" her system of weights and measures than this country has; or more correctly stated, Great Britain has proceeded on a definite plan of modernization for nearly a century, whereas the United States government has never done anything towards altering the standard of measures in use in this country.

There is a British law of the year 1266 still extant in which the legal standards for weight and volume are set forth; but this law was by its own evidence only an extension or addition to former statutes governing the subject which, however, have unfortunately been lost. Between 1266 and 1814 various measures were passed, but no definite system was followed. In the latter year a movement which had been on foot since 1736 culminated in the establishing of a commission for considering a plan of modernization of the British weights and measures, but in particular their decimalization. Their report being adverse to the latter, the present Imperial System was, after due consideration, established by law in 1824; and in 1835 another law was passed still further consolidating and improving this system.

During all this time, the decimal system (Metric and otherwise) was being agitated and great impetus was given to this agitation when the standards were destroyed by fire in 1834, and it became necessary to prepare new standards. This agitation increased from year to year and finally focused itself in an agitation for decimal coinage, which obviously formed and still forms the weakest point in the line of defence. This subject was exhaustively considered by successive committees and commissions until 1859, when the final report was such that decimal coinage was conclusively beaten, and so thorough was the defeat that the subject has never since been seriously revived.

The Imperial System of weights and measures has not been left to itself by the British Parliament, but was still further consolidated, improved and modified by the Weights and Measures Consolidation Act of 1878. By this act the troy pound (which is still standard in the United States) was abolished, together with the distinction between dry and liquid measure, and the cental of 100 lbs. was sanctioned for grain dealings.

The history of British law shows emphatically that your statement of Great Britain's negligence is not correct, and that the very opposite is true. We must not be led astray by various bills and propositions like the present Metric System agitation, which are always being from time to time introduced in Parliament; but the proper standard of judgment is what has been actually accomplished.

I have no intention of saying that the British system as consolidated is superior to that of the United States. On the contrary I think the legislators have made vital mistakes, and especially when the ten-pound imperial gallon was established and others abolished, for the reason that it was a new and wholly unwarranted departure from the original plan, and that it served to introduce another new standard of capacity with few advantages and many disadvantages. The United States gallon of 231 cu. ins. weighing 8⅓ lbs. in water is much superior for purposes of convenience; and this again shows the impropriety of a universal decimalization.

I will be met here by the sarcastic remark in some quarters that there was no original system in Great Britain; but people making this remark only exhibit their ignorance. In my paper on the metric system (Trans. Am. Soc. M. E., 1896) I have given some of the evidence which is sufficient to establish conclusively the existence of a very well-worked out system which was derived from the Romans. I take the liberty of repeating here what I have maintained elsewhere, that if the weights and measures system is to be improved at all, it is by returning to the original relations between the units of length, weight and capacity, and not by legalizing new and fortuitous relations.

However, the important point of this communication I have yet to make; which is, that legislation is a very inadequate remedy to the conditions you specify in Great Britain, and if not applied judiciously (as it scarcely ever is) is worse than the disease. This truth should be writ large in the minds of all who would tinker with a country's weights and measures: THAT TO INTRODUCE A NEW UNIT IS THE EASIEST THING IN THE WORLD, AND TO GET RID OF AN OLD ONE, THE MOST DIFFICULT. The history of weights and measures from Egypt to the United States is but one living and continuous illustration of this fact, which, however, is appre-

ciated by scarcely anybody; and this is why the seven-pound stone and its multiples up to 2,240 lbs., the absurd "cubic fathom" of 6 × 6 × 4 ft., and dozens of other incongruities are used in various parts of England. No legislation can form an adequate remedy for such conditions and the only possible remedy is to be found in actual commercial intercourse and commercial agreement between the leading industries. Your statement that the British coinage system is the cause of the defects of the weights and measures system is not correct, but both are derived from the same cause, and I am right in stating the very obvious truth that to decimalize the weights and measures while retaining the present coinage system would be a pure absurdity.

I have not the slightest hesitation in maintaining to-day the precise standpoint that I have taken from the beginning: "that the hope or belief" that Great Britain will ever make, by forcible measures, so radical a change as is implied in the adoption of the metric or a similar system to the exclusion of her own is perfectly visionary." And I repeat it in the face of the apparent imminence of the present proposed compulsory law. I do not consider it likely, notwithstanding its present support, that this law will ever pass the House of Commons; it waits only for the people to become sufficiently aroused by the danger to rise and defeat it, as they have always done before, and as they did in this country last winter. I do not say it might not be by some accident "jammed through." but supposing that this should happen, you will see what you will see.

George W. Colles.

Milwaukee, Wis., March 1, 1905.

PREPARING FOUNDATION-BEDS FOR SHORT RAILWAY BRIDGE SPANS WITH HAND-DRIVEN SHEET-PILING.*

By Walter N. Frickstad.

During the past four years, but chiefly in 1902 and 1903, the old Central Pacific Railroad through Nevada and Utah has undergone a transformation. Completed in 1869, part of the first transcontinental line, it was built when the standard of railway construction was much lower than in these days, and when the promoters had reason to congratulate themselves on putting through any kind of road. Then, as business developed, the southern route was undertaken by the same men, and the Central Pacific sacrificed to the new interests. Later, as the Government loan became nearly due, there was even less reason to expend money on what might shortly become United States property—in fact, it is said that at least one valuable bridge was moved during the refunding agitation to prevent it from falling into the hands of the Government if the question should be decided in that way. But after that was settled, the policy changed, and location parties spent years in seeking better lines around doubtful pieces of construction between Reno, Nev., and Ogden, Utah, and, later, from Sacramento to Reno. The cut-off across Salt Lake was discussed and surveyed during the latter days of C. P. Huntington's administration, and in May, 1900, a single construction party was sent to a ten-mile line-change near Lovelocks, Nev. That construction party supervised a small outfit of contractors who rebuilt twenty-five miles of line in the next year and a half, cutting out several bad hills and sharp curves. Then the present management took final control of the road, and in January, 1902, on the return of Chief Engineer Hood from a conference in New York, the work began in earnest.

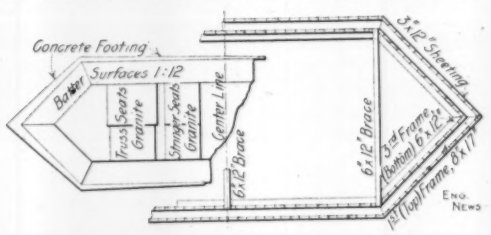

Fig. 1. Plan of Pier and Cofferdam at Ninth Crossing of Humboldt River; Central Pacific Ry.

Of this reconstruction, the Ogden-Lucin cut-off has often been described, but that, though the most expensive single line-change, and by far the most daring, was not even half of the "C. P. Reconstruction," as the whole project was named. From Reno to Browns, some 90 miles, not a mile of the old road-bed is in use to-day. From Golconda to Palisade, 108 miles, very little of the old line is retained, and from there to Umbria Junction, where begins the Ogden-Lucin cut-off of 104 miles, a large part of the line has been changed to reduce grades and flatten curves. Much of it is heavy grading, especially from Reno to Wadsworth on the Truckee River, near Golconda, and from Beowawe to Wells on the Humboldt, and across Promontory Point on Salt Lake. There are nine new crossings over the Truckee River, twenty-four over the Humboldt, and two over the Webber, near Ogden. And immense shops have been erected near Reno.

The crossings of the Humboldt River, numbered 3 to 12, are the basis of the observations here recorded. These bridges are located in Twelve Mile Canyon, near Palisade, Nev. There are ten crossings of twelve spans in a distance of five miles, besides one on the old line. Such an expensive line-change was made to improve a very steep and crooked piece of track. The maximum of 4° curves and 0.4% grade was not exceeded on the new line through this canyon.

The material encountered in the excavation varied from solid rock to what closely approached quicksand, but in general was firm gravel, and boulders underlying sand and river sediment. Few of the structures encroached seriously on the river channels, so the problem generally was to sink a hole large enough for the masonry on the edge of the river, where it was merely a case of holding the walls in place, pumping seepage water, and removing the earth, generally by shoveling from stage to stage until it could be thrown over the top.

The first structure erected was the east abutment of the 9th crossing, known to be located on a slope of rock that required little more than leveling. The cofferdam was to be 3 ft. outside the calculated bottom line of masonry at the greatest depth to which it was expected to excavate, this extra space being intended for drainage and exigencies of unexpected depth, encroachment of the dam, etc.

The dam was to be of sacks, L-shaped to cut off a triangle of water. It was to consist of a tier of sacks, a 3-ft. space for earth filling, then a double tier of sacks to resist the water current, all sacks being laid transverse to the dam. The longer leg was about 100 ft. long, and the short leg 40 ft. The sacks were filled with a mixture of sand, fine gravel and loam obtained on the site, were wheeled to the place, and deposited as carefully as possible by men provided with long-handled shovels and sticks to guide them into place. But it was not found practicable to build up the tiers in the regular form planned, for the sacks on their first immersion, filled as they were with air spaces, were easily disarranged by the current. The space left for puddle material became choked with sacks, but the work was completed as nearly according to plan as possible and the pump started. The only pump available at the time was an ordinary sewer "deluge" pump, supposed to be operated by one man. This failed to lower the water appreciably.

It was then decided to bank the whole river side of the dam with earth if the current could be prevented from carrying away the filling. That plan succeeded, though the current had become so confined by the encroachments of the dam that it swept past at about 5 ft. per second. To save the earth it was rushed into the swiftest parts by a steady stream of wheelbarrows, and as soon as the earth slope showed above water the coarsest gravel at hand was used to complete the fill and in a measure riprap the loam and sand. The whole was then pumped dry in two days and three nights by putting four men on each shift, two working and resting alternately in fifteen minute periods. This was at a cost of $19.20 per 24 hours, but that was better than waiting for power pumps.

While the masons were at work on the east abutment, the cofferdam of the center pier was started on a plan that thereafter proved to be the best of any used on the river—cheapest, most flexible, and requiring least equipment. Tests with long drills had shown loam or silt for 2 ft., gravel and boulders for 7 ft., and apparently rock at a depth of 9 ft.—afterwards found to be boulders, with rock at about 14 ft. The plan of the pier (Fig. 1), was that of a hexagon, and a heavy frame was built in that shape of 8 × 17-in Oregon pine, thoroughly drift-bolted together and braced to prevent rack or collapse. The pier was so located that the shore-line at the then stage of water crossed one corner, leaving about two-thirds of the proposed excavation in the river and one-third below dry land. The depth of the water increased gradually from the shore-line to the outer tip of the excavation, where it was 7 ft. Two feet of earth was cut out at the shore end, bringing that down to water level, then a pair of heavy horses 4 ft. in height was built and sunk in the stream at such depth that the tops were at water surface. Then planks were laid from the 8 × 17-in. frame to these horses, and the frame was raised on rollers of 1¼-in. water pipe. Two ropes, one on either side, were fastened to the out point of the frame and another to the landward end as a back-stay, then the frame was rolled out to place by four men with pinch-bars, three others attending the ropes as a precaution. Once in the approximate position, the frames were adjusted to line exactly with range poles in a very few minutes, the ropes were made fast and the rollers removed. The frame then rested on land and on horses beyond the center, one-third overhanging at about water level.

Under the three landward corners holes were dug about 2 ft. in depth and temporary posts set. Then the ground was excavated as deep as convenient under the frame, 3 × 12-in. planks were cut in 8-ft. lengths, and, starting at the sharp point, were stood on the outside of the frame and driven as deep as practicable with a heavy wooden commander. This commander consisted of a piece of railroad tie, mounted on an ordinary hammer handle and bound with rings of iron 1¼ × ⅜-in. These 3 × 12-in. planks were cut beveled so each would cling to the last driven, making a fairly tight joint. When ten or fifteen of these had been driven on each side, the trench was back-filled on the outer side with stable manure and loam. Then the lines of sheeting were continued out into the water, using longer planks as the work progressed, until the horses interfered. Then several of the last piles were heavily spiked to the frame, leaving heads of spikes standing out, however, for convenience in pulling; then the piles were driven deeper. Two 3 × 12 ins. were also spiked to the outer point as a further support, and the horses removed. Then the placing of the piles continued, and also the banking with manure and earth, until the site of the proposed excavation was surrounded by a line of 3 × 12-in. sheet piling and an impervious bank of earth. At the outer point, however, the full force of the current struck the earth bank, and it was soon found necessary to deflect it with a sack wing-dam and to riprap with coarse gravel and sacks.

The water was easily taken from this hole by the pump formerly used across the river. The bottom was found to be covered with a soft river silt, and the dam so tight that the leakage amounted to less than five gallons per minute.

Excavating now commenced in earnest with hand labor, the men throwing the material out over the short planks that had been placed at intervals. The material changed to gravel and boulders as soon as the surface had been removed, the gravel too firm to admit of driving the sheeting except as it was removed from below the points by shovel. It soon became apparent that the sheeting was sloping inward at the bottom. So a second frame, of 6 × 12-in., was built within the excavation at the bottom of the piling, then the driving of the latter continued, dropping the second frame as the excavation continued. At this depth it was found necessary to throw the excavated material on to intermediate stages supported by the upper frames and braces, and from there throw it over the piling. Only once was there any difficulty. Considerable material had been removed from below the piling at the river corner without following immediately with the piling. Suddenly the gravel caved and the excavation began to fill with river water and puddle. Two of the planks became loosened and fell out of place, but quick work with brush, manure and earth choked the hole, and no serious damage was done.

When the excavating had reached the depth at which it was expected to strike rock, some 7 ft. below the original water surface, nothing but boulders was encountered. Although the river level had been lowered by the failure of a small dam below, the limit of the piling had been reached. It was decided to go 6 ft. farther and found the pier on gravel and boulders if that material continued to that depth—unless rock were reached sooner, as new drill tests seemed to indicate. The lower frame now stood about a foot above the lower tips of the piling. On the bottom of the pit, so that its outside face should be 3 ins. inside of the inside line of the other two frames, a third frame was built of 6 × 12-in. Oregon pine, of the same form as the others. Then a second line of sheet piling was set between the two lower frames, short pieces being placed temporarily under the braces. The extra thickness of the rough timber made this somewhat difficult, and resulted in slanting the bottom outward, a very desirable feature. Fig. 2.

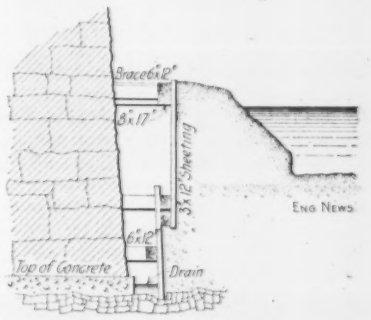

Fig. 2. Cross-Section of Cofferdam and Pier on Line A B, Fig. 1.

Shortly after the inside piling was started the flow of seepage water became too great for the two pumps available and work was discontinued. By the time other pumps arrived, the spring floods came on and water flowed over the top of the timber. It was in August when the work was resumed with a 6-HP. Fairbanks, Morse & Co. gasoline combined engine and pump. No further difficulty was encountered in sinking 5 ft. further, where rock was encountered lying nearly level, and requiring no dressing but the removal of loose particles. A footing course of concrete was laid varying in thickness from 3 to 15 ins., then the masons commenced their part.

The excavation for the west abutment, though much larger, was conducted in much the same manner as for the pier. This, however, was L-shaped. The frames were built in place after the site had been excavated to water level with slip-scrapers, and the second and third frames in due course. In lowering frames it was found that the pressure on the walls was so great that it was almost a hopeless task to use a commander or 16-lb. sledge. Even

*Extract from a paper in the "California Journal of Technology," November, 1904.

a 6 x 12-in. x 8-ft. fitted with handles and operated by two men, failed to make a satisfactory impression. Therefore, the shoveling platforms, 2 ft. wide and 16 ft. long, were loaded with gravel, one platform on each side of the section to be lowered, and a slight tapping produced any amount of settlement required.

Although hand piling is a common method of making excavations, it is seldom mentioned as a standard method of securing a foundation. Experience on the Humboldt River, however, indicates that its application should be extensive to foundations of a moderate depth—possibly to 20 ft.—in gravel, boulders, clay or coarse sand, or whatever ordinary power-driven sheet piling can be used, especially if the number required be so small that the freighting and building of a driver becomes a large item of expense per unit. On the Sixth Crossing, where the power-driven piling refused to penetrate more than 6 to 10 ft. in sand, an inside row of piling was set by hand and the excavation completed to the required depth. The work of setting frames and hand piling can be performed by one carpenter and enough helpers to handle the timber, and proceeds smoothly while the remainder of the gang excavates. The cost of excavating was high in the cases cited, but that was due to trouble with pumps, the small amount of material to be handled, the impossibility of obtaining derricks and engines to remove the material by power, and the difficulty of dealing with the "force account" men in the roundabout way through their employers, the contractors.

HIGH REINFORCED CONCRETE RETAINING WALL CONSTRUCTION AT SEATTLE, WASH.

By C. F. Graff, C. E.*

The Seattle Tunnel, which has just been completed, is a double-track structure, constructed by the Great Northern Ry. Co. for the primary purpose of relieving the congestion of traffic on the water front of Seattle. It is 5,141.3 ft. in length, face to face of portals, and runs in an approximately northwest and southeast direction underneath the business section of the city. Where the tunnel emerges in the down-town district, its tracks bear almost due south and lie parallel to and just west of the western margin of Fourth Ave. South. This street will form the eastern boundary of the extensive terminals planned by the Great Northern and Northern Pacific railroads; the proposed plan calling for 21 tracks, each 6,000 ft. in length, for each road, or an aggregate of about 48 miles of track. The difference in elevation between sub-grade of the railroad and curb grade of this street at face of south portal, is 37.47 ft. Allowing 0.33 ft. for proposed cement sidewalk, the difference in elevation between edge of sidewalk at street margin and sub-grade is just 37.8 ft. The grade of the street going south from the portal is — 3.075% to the first cross street, after which it slackens.

To hold back this street, therefore, a retaining wall, approximately 2,000 ft. in length and varying in height from 37.8 ft. above sub-grade at the portal to about 2 ft. above such grade at the opposite end, became necessary, and in order to compare the relative economy of plain concrete and reinforced concrete walls, comparative plans and estimates were prepared by the writer last summer, under the direction of Mr. Alex. Stewart, Resident Engineer, Great Northern Ry., Seattle, Wash. To make a fair economic comparison the

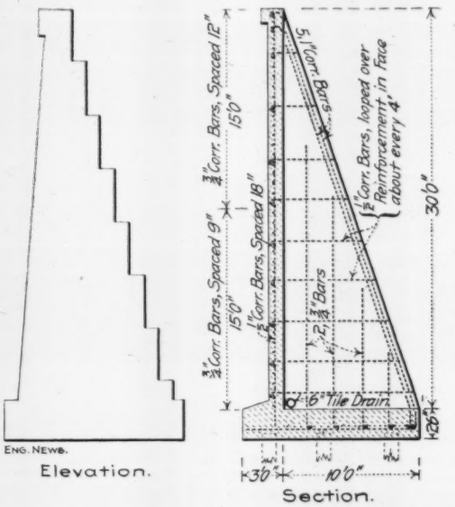

Fig. 1. Sections of Plain Concrete and Reinforced Concrete Retaining Walls Assumed for Comparison.

gravity wall was outlined as shown in Fig. 1, the base being in all cases 0.4 of the height, and the face batter 1 in 12. The amount of concrete per lineal foot of wall was then compared with the corresponding amount in the accompanying reinforced design, Fig. 1, plus amount of steel evaluated in terms of concrete at $6 per cu. yd. in place, this being about the cost of concrete to the railroad company. The steel was figured at 4½ cts. per pound in place. Comparisons were made for heights of 40, 30, 20 and 10 ft. clear above top of base, with results as follows: It will be observed that the saving in cost of the reinforced structure increases as the height increases, such saving amounting to 20.4% for the 12-ft. section and 45% for the 42½-ft. section. It is also evident that if a different rib spacing were adopted and the wall re-designed, another percentage of economy would result in each case; for a definite height of wall a certain rib spacing is the most economical, no doubt, but the writer did not have sufficient time at his disposal when the comparative plans were made to investigate this, nor has he since been able to take up the matter. It will also be noted that in this comparison as to economy, the extra cost of forms and scaffolding for the reinforced wall, and of better quality concrete than that required in the plain wall, are assumed to be counterbalanced by a saving in piling the foundation for the former style of structure on account of less superimposed weight.

Height of wall, ft.	Concrete in Plain wall, cu. ft.	Concrete in Reinf. wall, cu. ft.	Saving, per cent.
40	396.4	218	45
30	226	127.8	43.8
20	110	69.9	36.4
10	44	34.9	20.4

The results shown in the comparison were such that this general design for a reinforced wall was approved by Mr. A. H. Hogeland, Chief Engr., Great Northern Ry., and Fig. 2 is the detail plan of the first and highest section of the structure as actually built, this section, 127.5 ft. in length, having recently been completed. It will be seen that the general plan shown in Fig. 1 was revised slightly, one of these revisions being the addition of a 1 in 24 face batter, thus increasing thickness of face wall at the top of base somewhat, besides improving its appearance. This change, of course, necessitated a readjustment of the steel distribution in the face.

METHOD OF DESIGN OF 32-FT. 2-IN. SECTION.—The design of the wall was based upon the Johnson system of reinforcement. The formulas employed are those of average 1-3-6 rock concrete. In these formulas the following ultimate unit values are used: Modulus of elasticity of concrete in compression, 3,000,000 lbs. per sq. in., and of steel, 29,000,000 lbs. per sq. in.; elastic limit of steel corrugated bars, 50,000 lbs. per sq. in.; ultimate strength of concrete in compression, 2,000 lbs. per sq. in., and in tension, = 200 lbs. per sq. in. In designing the composite parts of the wall, the actual assumed bending moment has in each case been multiplied by the required factor of safety, and the resulting value used for purposes of design. The face and base of wall have been considered as composed of independent beams lying side by side, and an unknown factor of safety is thus introduced, inasmuch as there is really a floor slab action. The

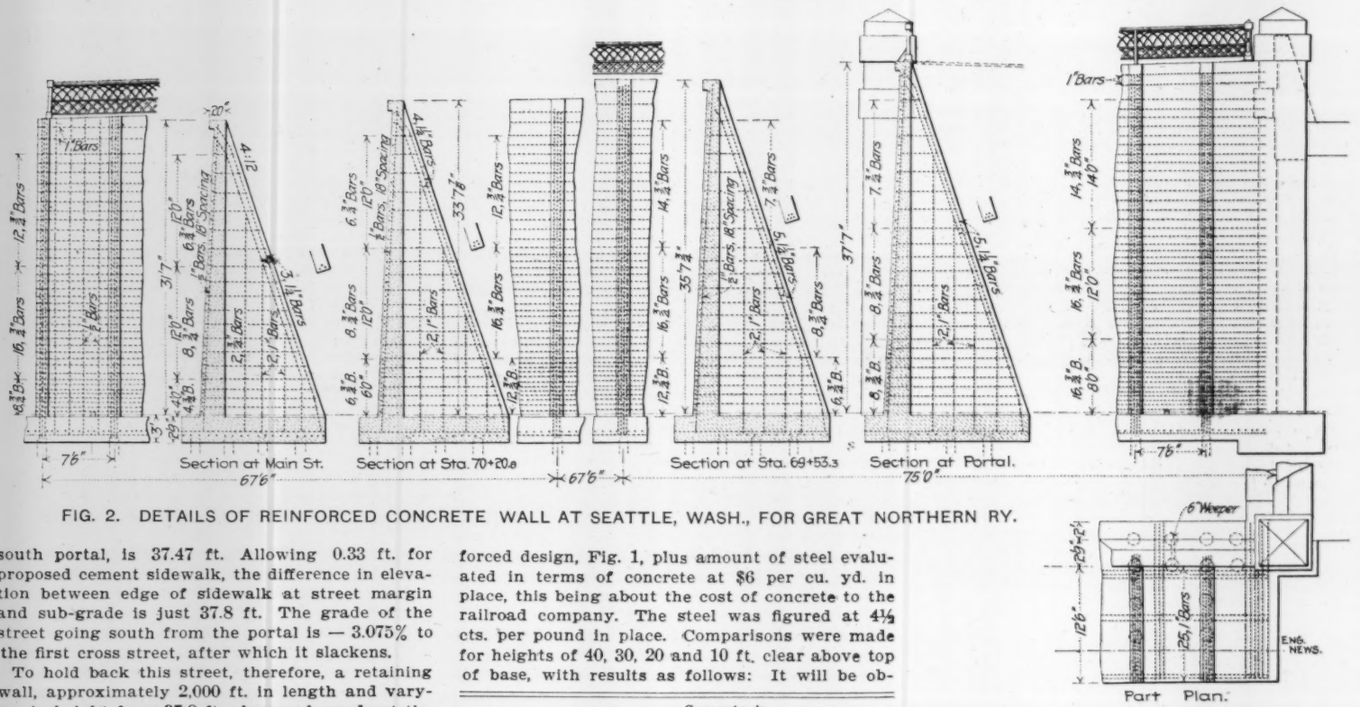

FIG. 2. DETAILS OF REINFORCED CONCRETE WALL AT SEATTLE, WASH., FOR GREAT NORTHERN RY.

*Great Northern Railway, Seattle, Wash.

weight of loose earth was assumed at 100 lbs. per cu. ft.; the weight of the wall itself was neglected in the design, which is on the side of safety as to overturning, and of no particular difference as to base; the lateral earth pressure behind the wall was found by means of Coulomb's theory and multiplied by 3-2, giving a factor of safety of about 3 against overturning, as values found by this theory are approximately twice too large by experiment. Where this wall is to be built there is a solid bank as backing where it is high, and it is improbable that the thrust will approach that computed.

WIDTH OF BASE (l).—Considering one wall foot,

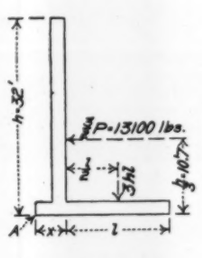

Fig. 3.

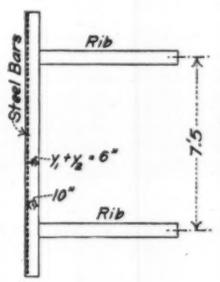

Fig. 4.

$$P = \tfrac{1}{2}\, w h^2 \tan^2 \tfrac{1}{2}\, A.\, C.\, D. = 13100 \text{ lbs.}$$

$$\tfrac{3}{2}\, P. = 19{,}500 \text{ lbs.} \quad \frac{P}{2} = 6500 \text{ lbs.}$$

Vertical earth pressure acts where shown, Fig. 3, and equals w h l where w is weight of 1 cu. ft. of earth = 100 lbs. Assuming x = 3 ft., and taking moments about toe at A, we have:

$$\tfrac{3}{2}\, P \frac{h}{3} = w.h.l. \left(\frac{l}{2} + x\right)$$

or $$\frac{3}{2} \cdot \tfrac{1}{2}\, w h^2\, 0.29 \frac{h}{3} = w.h.l. \left(\frac{l}{2} + x\right);$$

solving,

$$l = -x + \sqrt{\frac{h^2}{6.9} + x^2};$$

substituting numerical values

$$l = -3 + \sqrt{\frac{32^2}{6.9} + 3^2} = 9.4 \text{ ft.};$$

= 24,350 in. lbs; 24,350 × 4 = 97,400 in. lbs. By Johnson's diagram, $y_1 + y_2 = 6$ ins. $\frac{a^2 b}{d} =$ 0.5 sq. in. or ¾-in. rods spaced 9 ins. give excess strength. Adding 4 ins. outside of metal, h = 6 + 4 = 10 ins. (See Fig. 4.) As we go up towards the surface, the bending moment decreases, and bars may be spaced farther apart. W in above equation is the pressure of earth on lower 1-ft. strip, and is derived as follows: $\frac{P}{2} = 6{,}500$ lbs. is the pressure on a vertical strip of wall 1 ft. wide we go down, then letting p = unit pressure at

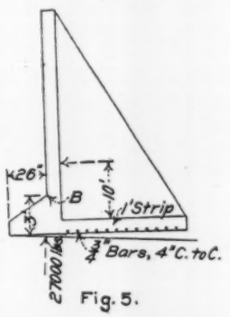

Fig. 5.

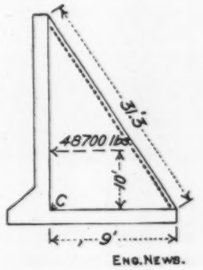

Fig. 6.

bottom, this total force of 6,500 lbs. must equal $\frac{p}{2} \cdot 30$ and p = 433 lbs.; as our beam is 7.5 ft. long W = 433 × 7.5 = 3250 lbs.

BASE OF WALL.—For longitudinal rods we assume as the most dangerous case that the wall is tipped as shown in Fig. 5. On outer or rear foot strip reaction is zero, and bending moment at center or half-way between ribs, caused by weight of earth on strip, is 167,000 in. lbs.; 167,000 × 4 = 668,000 in. lbs., $y_1 + y_2 = 13$ ins., h = 2 ft. 2 ins., to allow for piling. $\frac{a^2 b}{d} = -1.1$ sq. in., or ¾-in. bars spaced 4 ins. Spacing may be increased towards face of wall.

FRONT PROJECTION.—The bending moment at B = 27,000 × 26 = 702,000 in. lbs.; 702,500 × 4 = 2,810,000 in. lbs.; $y_1 + y_2 = 26$ ins. $\frac{a^2 b}{d} = 2.2$ sq. ins. or 1-in. bars spaced 4 ins. transversely. These bars will be run clear across base, though this gives excess strength. Make h = 3 ft.

RIB.—Pressure on rib = 6,500 × 7.5 = 48,700 lbs. Moment at C = 48,700 × 10 × 12 = 5,850,000 in. lbs. (Fig. 6.) Using factor of safety of 3 in this case we have bending moment of 5,850,000 × 3 = 17,550,000 in. lbs. Johnson's formulas for 1 : 3 : 6 concrete are M = 3,620 h², q = 0.077 h, where M is bending moment in inch pounds, h is depth of beam in inches, and q is area of reinforcement in square inches; substituting, we have h = 69.6 ins., q = 5.36 sq. ins.; the h in this case corresponds to width of rib at bottom, which is 9 ft.; hence q may be reduced to $\frac{69.6}{9 \times 12} \times 5.36 = 3.45$ sq. ins., and as the bars act at an angle with the vertical we will increase this in the ratio $\frac{31.3}{30}$, giving 3.6 sq. ins. Use five 1-in. bars.

RUPTURE BETWEEN RIB AND FACE OF WALL.—Force acting = 48,700 lbs. Letting X = tension in concrete per square inch we have 30 × 12 × 12 × x = 48,700. x = 11.25 lbs. per sq. in. A few bars will be placed horizontally through the rib for safety, though hardly needed, as a factor of safety of 4 would give only a pull of 11.25 × 4 = 45 lbs. per sq. in. on the concrete.

In the above analysis conditions have been assumed which are more severe than will actually occur. For instance, the wall will not tip as assumed in figuring the base, and the bending moments will probably not even approach those determined and used. Even under these conditions the saving of reinforced wall as against a gravity wall for this particular height is observed to be about 43%.

Vertical bars are placed in the ribs to tie them to the base. Investigation showed that the toe pressure was below safe supporting power of foundation.

METHOD OF CONSTRUCTION.—The excavation of the bank to a width and depth which would allow of building the wall was executed with some little difficulty on account of the height of the face, one or two slides taking place, necessitating clearing of the trench. The bank was excavated to a vertical face and held back by long rakers; the upper portion of this bank is a cemented gravel and the lower portion is a blue clay. The material will almost stand vertically, and it is not likely that any such pressures as were assumed in the design will ever be experienced by the wall.

Piles were next driven as shown in Fig. 2; the ground was hard, and the average depth of the

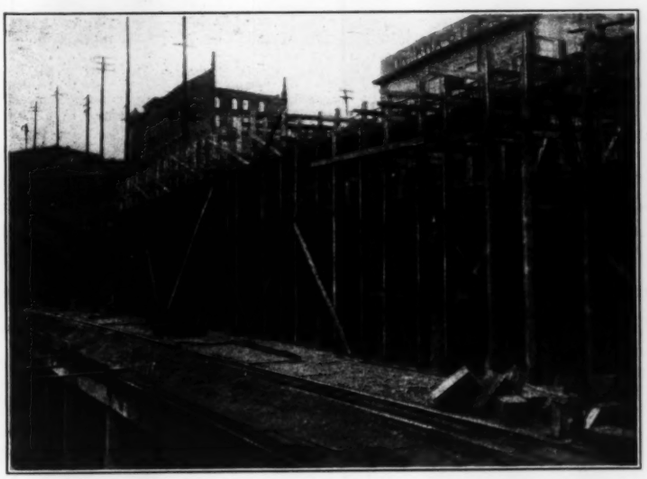

FIG. 7. VIEW OF SCAFFOLDING FOR ERECTING AND SUPPORTING REINFORCEMENT.

FIG. 8. VIEW SHOWING VERTICAL REINFORCING BARS IN PLACE.

9 ft. used in design, but base changed to 10 ft. later.

FACE OF WALL.—Assuming for purposes of design that the pressure increases directly as we go down, and considering the lower foot strip of wall as a beam of length equal to 7.5 ft., or distance between ribs, and fixed at both ends, the bending moment at center of same = $\frac{Wl}{12}$.12

piling below the bottom of the trench is only about 6 ft.; in fact, the soil is so compact that in the opinion of the writer, the base could have been placed directly on the same, if it were not for the fact that the concrete-embedded piling is counted upon to a certain extent in preventing the sliding forward of the structure.

The next step was that of erecting the steel bar skeleton, and to facilitate this a scaffolding was built as shown in Fig. 7; near the top of this scaf-

folding the two top 1-in. horizontal face bars were securely fastened in exact line and elevation, and the long diagonal 1¼-in. bars running down the back of each rib were hooked over these and swung into proper position at the bottom; some of these bars were 42 ft. in length, and were prevented from sagging by wooden cross-pieces nailed to the falsework. The ½-in. vertical face bars were then hung from the top horizontal ones and stayed at intervals in a similar manner; both these and the diagonals can be seen in Fig. 7. Next the vertical bars in each rib were placed, being stuck in the ground at the bottom and held at the top by wire tied to the scaffolding. Fig. 8 is a view of steel reinforcements taken from underneath the elevated platform at this stage of the work.

Concreting was now commenced, and the trench was filled to a height of 3 ins. above the top of the piling, and the horizontal longitudinal bars were placed, the whole section of 127.5 ft. of wall being built up simultaneously. As the work proceeded, the horizontal bars in the face and in the ribs were placed in proper position, care being taken always to lay the bars on fresh concrete, and arrange the laps at ribs, such laps being 2 ft.

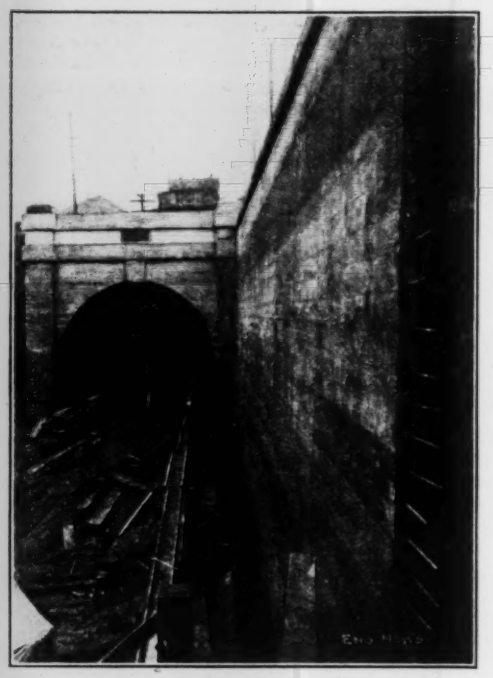

Fig. 9. View Showing Face of Wall and Tunnel Portal.

in longitudinal base bars, and 1½ ft. in face bars. The concrete was mixed fairly wet, laid in 6-in. layers, and thorough tamping was demanded. A 1-2-4 trap rock mixture was used. The voids in the rock and sand were 43% and 33% respectively. The Condor brand of Portland cement was used, and one barrel made just ⅔ cu. yd. of concrete in place. Mixing was done by hand. For the base and lower portion of wall this was done on the ground along face of trench, and for upper portion on the elevated platform running along face of wall, as seen in Fig. 7. Cars carrying the materials were hauled up on this platform by means of a stationary engine and cable. The tunnel portal was built up with the wall, and the horizontal base and face bars imbedded in the portal post. No backfilling will take place for three weeks from date of completion of structure.

Fig. 9 and Fig. 10 are views of the finished wall, the former taken for the purpose of indicating the projecting steel bars, on which the main reliance will be placed in forming a good bond with the next section of wall when same is extended. Such extension will take place in the immediate future.

The work here described was done by force account under the general charge of Mr. A. H. Hogeland, Chief Engineer, Great Northern Ry., and under the immediate charge of Mr. Alex. Stewart, Resident Engineer, Great Northern Ry. The writer inspected the construction of the structure.

DECISION ON APPEAL IN THE DAYTON, OHIO, ELECTROLYSIS LITIGATION.

Nearly three years ago Engineering News reported the primary decision* in a suit brought by the city of Dayton, O., against the City Railway Co., which operates a trolley line in Dayton, on account of serious destruction of water pipes by electrolytic corrosion due to stray return current from the trolley system. The same suit has now come to a decision on appeal from the Common Pleas Court to the Circuit Court.

The original suit was brought, not with the object of obtaining compensation for damage caused, but to secure a mandatory injunction commanding the street railway company "to adopt a new system of traction (the double trolley system.—Ed.) and such devices as may be necessary to prevent the electricity from damaging said water-pipes of said city and its inhabitants." Facts as to the legal and physical conditions of the matter in dispute were presented at great length; experts for both sides testified, exhibits were submitted and illustrative experiments performed in court. The findings of the judge, which went into much detail, upheld most of the allegations of fact made by the city and discredited those of the defendant company. Yet the relief prayed for was not given.

The crucial point in this primary suit was three-fold: partly of law, partly of physical fact, and partly of ignorance: (1) The governing franchises authorized the company "to operate said road by animal, electrical or cable power," and to use "trolley or storage electric or cable motive power for the purpose of propelling its cars." The court, after subtile analysis, holds that this implicitly authorizes the company to construct and operate the single-trolley system, and this in turn, according to precedent decisions, absolves the company from liability for damages provided its right is exercised with reasonable care. On this ground the lower court adjudges itself powerless to issue an injunction commanding a change in method, since, it says, the change in method implies a change in contract. (2) The bonding of the defendant company's track was proven to be in very poor condition, and it was also proven that poor bonding would increase the electrolytic damage. (3) There was no existing knowledge that the damaging electrolysis would continue if the track system were properly bonded and equipped with return feeders; the court could find no convincing evidence that the proper bonding and repair of the track system would not obviate future damage, and instanced the city of Hartford, Conn., as a locality where a system properly equipped with bonds and rail returns, but without insulating joints in the pipes and without connections from pipes to rails and pipes to dynamos, had proved successful.†

The conclusion was as follows:

It is, therefore, the duty of the Court to enjoin the defendant from so operating its railway and to compel it, within a reasonable time, to introduce such improvements in its system, in order that the operation of the single-trolley system, authorized by the franchise and contract, will be in accordance with the present standard of the art of operating single-trolley roads. The plaintiff shall cooperate to that end.

It will be seen that in effect this was a decision against the city of Dayton; for, the decision defined the franchise contract as authorizing the single-trolley system, and specifically debarred the city from securing relief or redress for electrolytic damage so long as the road were operated "in accordance with the present standard of the art of operating single-trolley roads," as quoted just above. In consequence, the city appealed the case to the Circuit Court, whose decision was rendered about two months ago.

The Circuit Court, in effect, upholds and reaffirms the conclusions of the lower court; but these conclusions are more carefully and consistently stated, as appears from the reprint below. The decision in full, reprinted in the Dayton "Daily News" of Dec. 22, 1904, recites the causes of the action and the general merit of the several contentions; it emphasizes the fact of very poor construction and maintenance of the trolley company's track return system; and points to the fact that no clear conclusion can be reached as to whether further damage would be obviated if the road "is brought up to the present standard of the art, the best known appliances used and the road kept in repair and operated with reasonable care." The actual findings of the Court are stated at the close of the decision as follows:

It must be conceded that the defendant has the right to a reasonable use of the power granted it by the city, and such use must be exercised with due care; but it is not made clear how the court is to determine whether the railway has abused the franchise in the selection of the system adopted for the application of the electrical current, when the testimony offered shows that part of the mischief is due to the negligent construction and operation of the road; and how much is traceable to these causes the testimony fails to show.

In view of the fact that the expert witnesses differ as to the quantity of current sufficient to cause electrolysis, how can the court say that, after the construction of the road is up to the present standard of the art and is operated with due care, the current then diverted, if any, to the water pipes of the city will cause electrolysis or constitute actual negligence on the part of the railway in the use of the single trolley?

Under the grant to the dependant by the city to equip with the single trolley, in the use of that system the defendant would be liable only for actual negligence. In granting such right the city must be taken to have contemplated, and condoned by anticipation, any mischief arising from the reasonable use of such system.

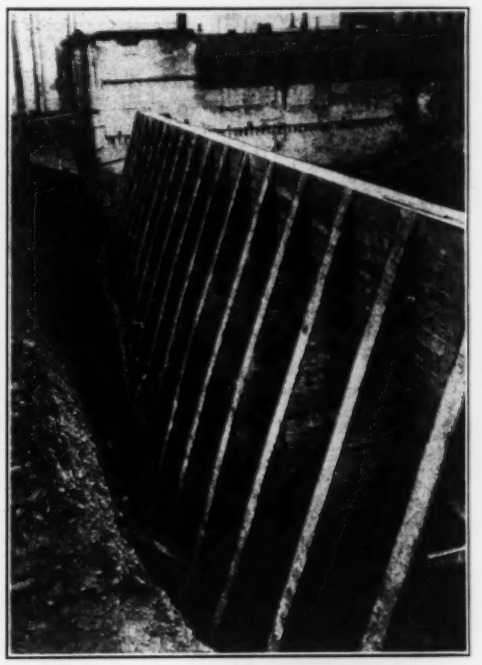

Fig. 10. View Showing Rear of Wall.

When a corporation is exercising delegated authority for the public benefit by the use of due care, no action will lie against the corporation resulting from the proper exercise of the authority.

The law authorizes the action of the city.

The case presented does not authorize the court to require defendant to change to another system.

The faulty construction of the defendant's road and negligent operation of the same result in a continual damage to the water pipes of the city for which it has no adequate remedy at law.

The fact that other electric railways operated in the city by the same system are in part responsible for the injury to the city's water pipes constitutes no defense for the defendant.

The defendant will be enjoined from operating its road in the condition shown by the evidence, and from negligently operating the same.

Jurisdiction of the case will be retained, to give the defendant an opportunity to show what, if any, improvement it has made since the cause was submitted to this court, in the way of bringing up the construction of the road and in operating the same.

*Engineering News, April 17, 1902, p. 316.

†There has been complaint of electrolytic damage in Hartford, and in the case on appeal in the Circuit Court this fact was clearly shown, controverting this portion of the primary judge's findings.

TRACK ELEVATION AND DEPRESSION AT MILWAUKEE.

The city of Milwaukee, like a number of other large cities, is facing the problem of separating the grades of railways and streets so as to abolish grade crossings. There are two reasons for this. First, the elimination of the dangers due to these grade crossings, and, second, the elimination of the delays to street traffic (including fire depart-

ment equipment), especially where long freight trains pass at low speeds. A commencement has already been made at Milwaukee; one piece of line has been depressed, an ordinance has been passed and accepted for the elevation of another line, and ordinances have been drawn and pre-

Fig. 1. Map Showing Track Elevation and Depression at Milwaukee, Wis.

liminary arrangements made in regard to still other lines, so that the work of eliminating the grade crossings will be spread over a number of years.

The accompanying map, Fig. 1, shows the railway lines of the city. The Chicago, Milwaukee & St. Paul Ry. enters the city from the south and is above the street level as far as Lincoln Ave., where there is a subway. Beyond that it is on the street level to the Union Station and west through the freight yards and lumber district of the Menominee valley to the city limits. The Madison line continues westward, but the line to St. Paul branches off and re-enters the city, running north to the city limits. The Chicago & Northwestern Ry. lines from Chicago and Madison enter the city at the south and run to the station on the lake shore, thence continuing north along the shore and the Milwaukee River.

TRACK DEPRESSION.

The piece of work already completed is the depression of the main tracks of the Chicago & Northwestern Ry. where they pass through the northeastern part of the city, as shown at A, A, on Fig. 1. This depressed line has three tracks, but the width between retaining walls and bridge abutments is sufficient for four tracks, so that only the widening of the cuts and banks will be necessary when the additional track is required. At present, the western track is used to serve industrial establishments, into which spur tracks are laid. Part of the line has retaining walls on both sides or on one side only, the remainder being mainly through cuts, with some side hill work along the Milwaukee River. To allow for the additional tracks at the south end of the work, the embankment along the lake shore (rising from the station to the higher ground) was widened, the foot of the slope being protected from the waves by a concrete retaining wall. The maximum depression was from 18 to 20 ft., and the city lowered the sewers and water mains so as to place them about 5 ft. below the level of subgrade.

The clear width between retaining walls is 63 ft., and these structures are of stone masonry. The railway company has a quarry of its own and prefers masonry to concrete for such walls; and under the circumstances it finds it quite as cheap as the latter. Sections of this wall at different points are shown in Fig. 2. Most of the street bridges are plate girder structures, but there are some truss bridges, including one of 117 ft. span which carries a street crossing the tracks at a considerable angle. All the bridges have solid floors, with 18-in. I-beams spaced 39⅜ ins. c. to c. for the roadway, and 78¾ ins. for the sidewalks. Concrete is filled in around the beams and forms arches between them, on expanded metal centering. The concrete entirely surrounds the beams, so as to protect them from the action of smoke and gases, as shown in Fig. 3. The roadway is paved with vitrified brick on a sand cushion, while the sidewalks are of concrete, reinforced by expanded metal. Where street railway tracks cross the railway, the streets and tracks were elevated and carried on temporary Howe truss bridges before the railway depression work was commenced, so that this work could be carried on and the permanent bridges built without interference with the electric cars.

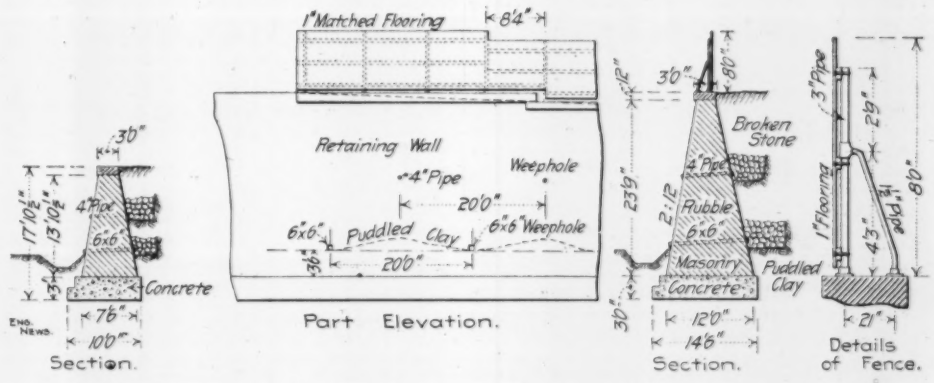

FIG. 2. RETAINING WALLS ON TRACK DEPRESSION WORK AT MILWAUKEE, WIS.; CHICAGO & NORTHWESTERN RY.

TRACK ELEVATION.

The Chicago & Northwestern Ry. has accepted an ordinance providing for the elevation of the tracks of its Madison Division in the southeast part of the city (shown at B, B, Fig. 1), from the city limits to Greenfield Ave. An ordinance is pending for the elevation of the Chicago, Milwaukee & St Paul Ry. tracks, which parallel those of the Chicago & Northwestern Ry. from Lincoln Ave. to Greenfield Ave. (shown at C, C, Fig. 1), including part of the spur connecting with the Chicago line of the latter railway. Negotiations are also in progress in regard to the lines of the Chicago, Milwaukee & St. Paul Ry., running west from the Union Station. A plan for the elevation of this company's lines from the southern boundary of the city to and through the Union Station was prepared by the City Engineer a few years ago, but was not adopted, and the work will be done in sections. The two pieces of work next to be undertaken (B, B, and C, C, Fig. 1), however, will not be executed for some time, as the federal government has decided to widen, deepen and improve the Kinnickinnic River, and until the new harbor lines are established the railways cannot definitely locate their bridges.

The following general description of the work required for the track elevation of the Chicago & Northwestern Ry. in the southeastern portion of the city is compiled from the ordinance governing this work. The company may build embankments with side slopes or with retaining walls, and cross streets and alleys with steel girder bridges supported on concrete or masonry abutments, or upon rows of iron or steel columns braced together laterally and erected on masonry foundations built within the line of the right of way, and in the centers and curb lines of the streets. Solid floors or open floors may be used, but in the latter case some means must be provided to prevent dirt, water, etc., from dropping into the subway. The clear headway in the several subways is to range from 12 ft. to 13½ ft. Some of the streets will be lowered at the subways, and where the head of the approach grade connects with the present level of the street a vertical curve is to be introduced extending not less than 10 ft. on each side of the grade intersection; the middle ordinate of this curve will be equal to half the difference between the elevation of the points on the intersecting grades. The grades of the approaches are not to exceed 4%. The subways will have brick paving for the roadways and cement sidewalks; the railway company must pay for all this, except that where street railway tracks exist the tracks must be laid and the space between them paved by the street railway company. If additional subways (not provided for by the ordinance) should be required in the future, they are to be built by the railway, but at the expense of the city.

The works above mentioned are, of course, only the commencement of a general scheme of separation of grades, which is becoming more and more necessary with the growth of the city and the increase in street and railway traffic. The city pays no part of the expenses, but agrees to defend any suits brought against the city or the railways for damages to adjacent property or business claimed to result from the execution of the work.

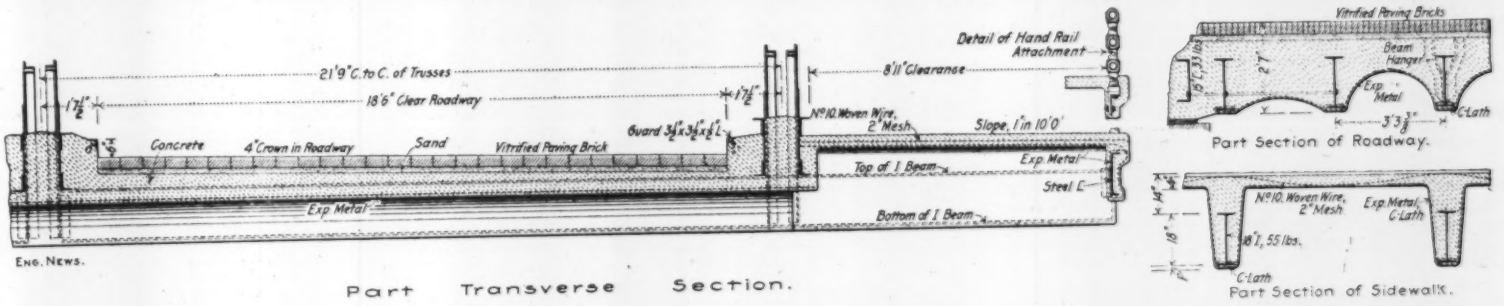

FIG. 3. FLOOR CONSTRUCTION OF HIGHWAY BRIDGES OVER THE TRACK DEPRESSION OF THE CHICAGO & NORTHWESTERN RY. AT MILWAUKEE, WIS.

ACCURACY TESTS OF WATER METERS AT DES MOINES, IA.*

By Chas. B. Burdick.†

It is customary and necessary in all well-regulated water-works to make periodic tests of the water meters in service to ascertain whether they are properly registering. Although much meter testing is done, very little has been published of the results of tests upon meters that have seen service.

It has been the policy of the Des Moines Water-Works Company to test each meter in service once a year. In 1897, however, owing to the rapid growth in the number of water consumers there existed a large number of meters which had not been tested for two or three years. In order to ascertain just what these meters were doing, it was determined to make a general test covering all the meters or so many of them as should be necessary to demonstrate that they were operating satisfactorily.

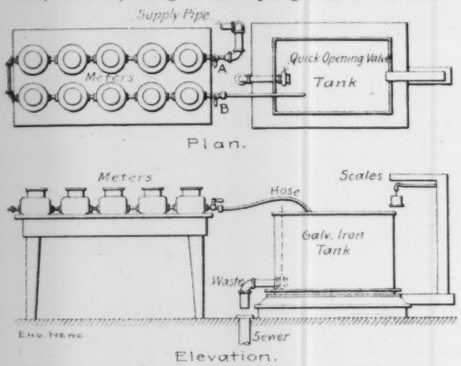

Fig. 1. Apparatus Used in Making Accuracy Tests of Water Meters at Des Moines, Ia.

The writer was placed in charge of the testing room in Sept., 1897, and during the fall and the following winter, 1064 meters of various makes and sizes were removed, tested and replaced, many of them being also repaired.

The first meters tested were selected with especial reference to facility of removal, all those in a certain locality being removed at one time. A summary of the first 400 meters, however, showed such favorable results that it was decided to confine subsequent testing to those meters most liable to be in error, and subsequently, meters were selected from the lower levels of the city where it was believed the greater head coupled with the greater shocks caused by numerous hydraulic elevators subjected the meters to greater deterioration than in the high districts of the city, and also to meters supplying consumers who used more than 3,000 gallons per month as determined by their Feb., '98, bill. The 1064 meters included practically all of that class.

The meters were tested in the workshop and testing room of the water company. The removing and setting of the smaller meters was ordinarily done by one man with a one-horse wagon. At times there were two or three men gathering the meters working independently.

The man would leave the shop in the morning with about a dozen tested meters in his wagon. Arriving at the house of a consumer the water was shut off at the cock just ahead of the meter, the meter removed and a tested one inserted in its place, the water was then turned on and the man moved to the next nearest place, returning to the shop at noon and again at night with from 8 to 12 meters. The removal and resetting of from 16 to 25 meters by one man was considered a good day's work.

The meters were usually located in the cellars of the houses supplied. Many of them were set in pits outside. Upon being brought to the testing room the outside of the meter case was brushed clean, many of them coming from damp places and being coated with rust and dirt, and immediately tested without examining the interior, the idea being to gain a close idea of what the meter was doing in service.

The testing apparatus consisted of a bench about 2 by 5 ft. upon which the meters were connected up, and a rectangular galvanized iron tank resting upon a platform scale. The tank was provided with a waste connection controlled by a quick opening valve and an elbow looking into the mouth of the sewer without touching it. The water was measured by weight using 62½ lbs. as the weight of one cubic foot.

Fig. 1 shows a plan and elevation of the testing rig. Brass cocks were placed at A and B, and into cock B was screwed a short piece of rubber hose which led the water from the last meter into the measuring tank. Preliminary to starting a test the smaller meters were usually connected up in series of 8 or 10 as shown in plan upon Fig. 1. The lost head limits the number possible to test at one time to about this number.

The method of procedure was as follows: Having the meters connected up as shown, the waste valve of the measuring tank was opened, also cocks A and B, and water enough passed through the meters to free them from air. The waste valve and cock B were then closed, the scales balanced and set and the meters read and recorded. The proper rate disk being placed in cock B, the cock was then opened and the water allowed to flow uniformly until the scale beam tipped when cock B was closed, and the meter again read and recorded.

If the meter is in perfect order the difference between the two readings will correspond to the water weighed. Ten cubic feet of water or a multiple thereof was always run and, therefore, the per cent. registration of the meter could be directly read, with no further calculation than subtracting the first reading from the second.

The first meters were tested under five rates of flow, the rate being controlled by the insertion of a perforated brass disk or washer in the outlet coupling of cock B. The rates of flow corresponding to the various sized disks were as follows:

Hole.	Cu. ft. per minute.
1/32-in.	.035
1/16-in.	.10
⅛-in.	.36
¼-in.	.97
½-in. (no disk)	1.2

After enough meters had been tested to well establish the general form of the regulation curve, we omitted the test with the ⅛-in. and ¼-in. disk.

The meters larger in size than ½-in. were tested singly using the same-sized disks as above. The flows, however, through the larger disks were greater with meters tested singly owing to less lost head.

In testing a set of meters the largest flow was passed first, and if the registration of any meter varied more than 2½% from correct, the meter was opened and examined. It frequently happened that cleaning the intermediate gear restored the meter to good working order. Oftentimes accumulations of various detritus washed from the pipes caused the meter to work hard. The most frequent cause of error, however, was wear of the pistons or disks.

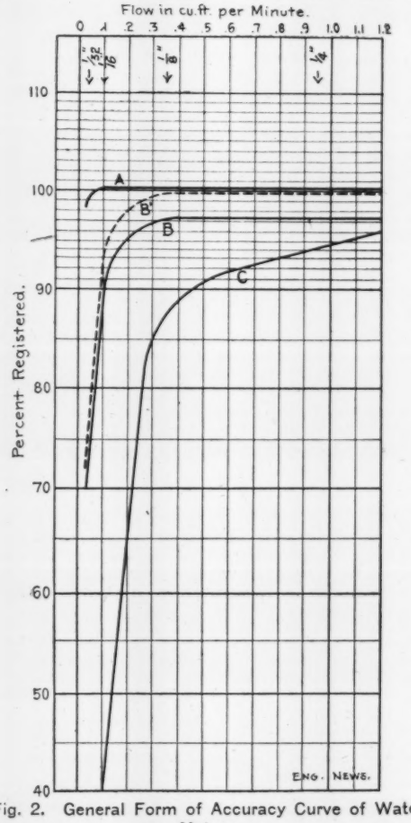

Fig. 2. General Form of Accuracy Curve of Water Meters.

A Represents a meter in good condition.
B Represents a meter somewhat worn.
B' Represents B corrected by changing the gear ratio.
C Represents a meter badly worn.

If a meter required more repairs than a cleaning, the test was run through and the meter set aside for repairs after which it was retested and returned to the service.

Fig. 2 is intended to illustrate the effect of wear upon both the piston and the disk type, the Worthington meter possibly excepted. It will be seen that the rate of flow in cubic feet per minute is laid off as an abscissa to the right, and the per cent of registration is laid off from the bottom of the diagram upward as an ordinate. The upper curve shows a test of a new and perfect meter; the middle curve shows a meter slightly worn, and the lower curve shows a meter badly worn. It is seen that wear affects a meter to the greatest degree at the small rates of flow, the registration of the badly worn meter being nearly correct at the maximum rate of flow, but falling off badly at the smaller rates and ceasing to register altogether at the smallest flow.

A defective registration may be corrected in several ways. As before stated a good cleaning is often sufficient. The most frequent cause of error, however, is wear. If the error is small, and the registration holds up fairly well on the small flows, the meter can be corrected by removing one of the wheels from the intermediate or reducing gear and inserting a wheel with one or two more teeth, thereby speeding up the registration gear. This was our practice at Des Moines. A meter that registered over 97.5% of the true flow was not repaired. Meters that registered from 92.5% to 97.5% were speeded up by changing the gear ratio, all meters showing a less registration, particularly if they fell down on the small flows were sent to the shop.

The dotted curve in Fig. 2 shows meter B corrected by changing the gear ratio. It will be seen that this affects the curve by raising it nearly evenly throughout its entire length.

Meters of the Crown and Hersey type were most worn upon the surface of the lower plate and upon the lower or rubbing end of the piston. Upon the old style Crown meters, the lower plate is permanently fastened to the crown or ring surrounding the piston. It is impossible in any ordinary lathe to surface such lower plates. An attempt, however, to repair these meters locally was made, a sheet of tissue paper was laid in the lower plate, the piston set down and wedged in place. The meter was then set in a lathe with the top plate off, and the ring and the top of the piston turned down true and flush. The removal of the tissue paper left just enough play between the piston and plates. This greatly improved the registration of the meter, but if the lower plate was

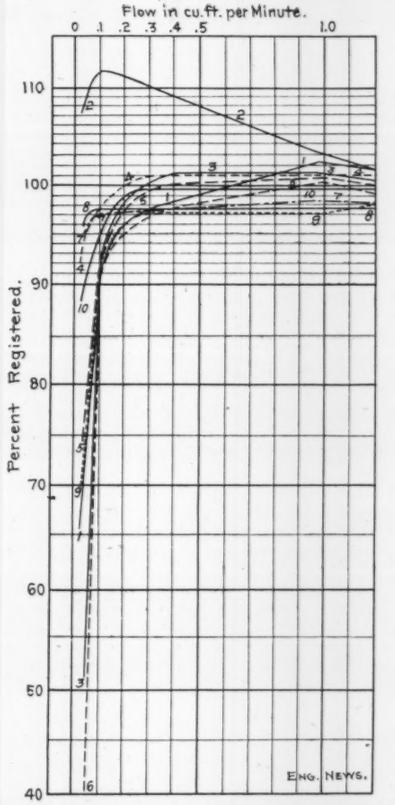

Fig. 3. Average Results of Tests of ½-In. and ⅝-In. Water Meters at Des Moines, Ia.

Curve number.	Make.	No. meters tested.	Years' service.
1	Hersey Disk	32	1 to 4
2	Worthington	5	15 to 20
3	Union	14	10 to 14
4	Nash	40	1 to 3
5	Trident	80	½ to 2
6	Hersey Piston	197	4 to 10
7	Crown A-A	88	1 to 3
8	Crown A	97	3 to 6
9	Crown Old Style	372	6 to 15
10	Empire	18	1 to 3
	Total	943	½ to 20

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers.

†Consulting Engineer; 1207 Hartford Building, Chicago.

much worn it was always more or less grooved and such a meter could only be made perfect by sending to the factory and having the lower plate faced. The newer meters having removable bottom plates, were easily repaired by first facing the lower plate fitting it again in place and turning down the ring and the piston together as above described. The repairs to the disk meters consisted principally in gearing them up and occasionally replacing a defective disk.

Fig. 3 shows graphically the results of the registration tests on ½-in. and ⅝-in. meters the rate of flow being laid off to the right and the per cent. registered vertically as before explained. The meters are grouped according to make. Each curve represents the average of all meters tested of that particular size and kind.

It will be noticed that all curves are quite similar. The registration curves of small meters being practically horizontal between flows of 0.3 and 1.2 cu. ft. per minute and from the small flow falling off sharply. The curve of the Worthington meters is, however, different, registering higher upon the small flows than upon the large flows. This phenomenon is probably due to a short striking of the pistons under conditions of slow movement. Only five meters of this make were tested and they were almost old enough to vote.

The character of the water at Des Moines is quite favorable to the water meter, being from underground source and entirely free from sediment. The pressure ranges from 50 to 100, depending upon the elevation of the consumer.

It is considered that the above tests speak well for the accuracy of the water meter, especially in view of the considerable age of many of the meters tested. The results exceeded our expectations.

THE HUGE "CARONIA" of the Cunard line arrived at New York on March 5, completing her maiden trip across the Atlantic. Our statement in our last issue that she is the largest of passenger steamships should be modified, since the "Celtic," "Cedric" and "Baltic" of the White Star line and the "Minnesota" and "Dakota" of the Great Northern Transpacific line, each excel her in actual tonnage displacement. All these vessels, however, have much lower speed than the "Caronia." The "Baltic," for instance, has engines of 13,000 I. HP., as compared with the 20,000 I. HP. of the "Caronia's" engines. The "Baltic," moreover, can carry about 28,000 tons of freight, while the "Caronia's" capacity is 13,600 tons. The "Caronia" has accommodations for 3,100 passengers and carries a crew of 400. The third-class passengers are provided with individual staterooms with two, four and six berths, and a degree of comfort is afforded which is in sharp contrast to the steerage accommodations of only a few years ago.

To give some idea of the enormous size of the "Caronia" by comparison with familiar objects on land, it is stated that if she were placed on the east side of the Capitol at Washington she would entirely hide that great building save about 38 ft. at either end, and not even the roof line, except the dome, would be visible over her upper decks. The captain's bridge on the "Caronia" is 97 ft. above the keel and the tops of the two huge smokestacks are 150 ft. above the keel. Their diameter is such that two full-size standard-gage locomotives could pass through them side by side.

The engines are fitted with the Yarrow-Schlicht-Tweedy counterbalances to diminish vibration, and the hull has the largest bilge keels ever fitted to a vessel.

The "Carmania," a sister ship to the "Caronia," of exactly the same dimensions but equipped with three turbine driven screws, will be ready for service in a short time. The two great turbine driven ships of 25 knots speed for the Cunard line are expected to be put into service early in 1907.

EMPLOYMENT OF AMERICAN ENGINEERS on the Grand Trunk Pacific Ry. was reported on by Judge John Winchester, who was appointed a Commissioner by the Canadian Government to investigate the charges of discrimination against Canadian engineers in filling positions. His report, as published in the Montreal "Daily Witness" of March 3 is in part as follows:

As the result of the evidence taken before me during the investigation, I am of opinion that there was no earnest endeavor made to obtain Canadian engineers for the location of the Grand Trunk Pacific Railway by those having authority to employ such; that had such an effort been made, there would have been no difficulty in obtaining a sufficient number capable not only of locating but of constructing the whole work.

In the word "engineers" I include all from the chief engineer and harbor engineer to the transitmen, draftsmen, levellers and topographers. There was, however, a very earnest desire to obtain American engineers for the work, and in some cases applications were made to the heads of other railway companies to relieve men for the purpose of having them brought to Canada to be employed on this road. I find also from the evidence that the Canadian engineers are not inferior to the American engineers for the work in question, but having a superior knowledge of the country they are better qualified for that work. I also desire to state that the Canadian engineers are not asking for protection for themselves, but merely desire that no discrimination be made against them. That discrimination has been made against them, in my opinion, there is no doubt.

The commissioner finds that the chief positions on the Grand Trunk Pacific surveys were distributed as follows:

	Americans.	Canadians.
Chief Engineer, $7,500	1	..
Div. Engineers, $4,000 each	3	..
Dist. Engineers, $3,000 each	2	1
Office Engineer, $2,400	1	..
Harbor Engineer, $3,000	1	..
Asst. Engineers, $1,800 to $2,100 each	6	14
Transitmen, $1,200 each	7	12
Draftsmen, $900 each	5	16
Levellers, $900 each	3	14
Topographers, $900 each	2	13
	31	70

THE RAILWAY TERMINALS of Cincinnati, O., are likely to be enlarged and improved at very considerable expense. The Cincinnati Southern Ry. is already at work on new freight terminals to cover about four large city blocks, with team yards and concrete freight houses. Other railways are planning individual improvements of a similar character. For general improvements a freight belt railway is proposed to relieve the present congestion and to facilitate the interchange of through cars. This project is under consideration by a commission representing the business interests of the city and the railways; Mr. G. H. Waldo, who recently resigned as General Manager of the Cincinnati, Hamilton & Dayton Ry., is investigating the matter on behalf of the commission. The passenger terminal system is also unsatisfactory and a new union passenger station on the south side of the Miami Canal, between Elm and Walnut Sts., is proposed by the Union Terminal Ry. Co., an independent company, of which Mr. T. H. Woodard is President. Underground lines running east and west would connect with all railways entering the city on both sides. The Pennsylvania R. R. is proposing to extend its passenger line further into the city to a new terminal station at Fourth and Walnut Sts.; this would also probably be used by the Louisville & Nashville Ry., which shares the present Pennsylvania R. R. station. As a modification of this project a central union station on the south side of Third St., at Walnut St., has been proposed by Mr. E. A. Elzner, architect. This plan provided for a large open square south of Third St., fronting the station, and beneath this square (which would be on side hill ground) was to be a terminal for the city and interurban electric lines. Elevated lines would connect the union station with the railways entering the east and west sides of the city.

A WIDE APPLICATION OF THE TESLA POLYPHASE patents was made by Judge Seaman in the Federal Circuit Court at Milwaukee, Wis., in the decision in a suit brought by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., against the National Electric Co., of Milwaukee, Wis. The complainants, owners of the Tesla polyphase patents, sought to enjoin the defendant from the further sale of synchronous motors (reversed alternating-current generators). Their contention was that the claim of Tesla for producing a rotating field by means of currents differing in phase applies to synchronous polyphase motors and rotary converters as well as to induction motors. This contention was upheld by the court. The material portion of the decision delivered Feb. 24, 1905, is reproduced in the "Electrical Review" of March 4, from which we quote the following:

Whether the effect of the Tesla invention in its production of the "whirling field of magnetic force" is identical with that of a rotating physical magnet, as argued by experts and counsel, does not impress me as material to this issue. Nor does it seem material that in the one form of motor "the rotation is produced by the unaided effect of alternating out-of-phase currents," as described by counsel, and that so applied a self-starting motor is obtained. The discovery was of means and method in the polyphase rotating field motor to produce the whirling field of force, and employment thereof was patentable with or without direct-current excitation of the armature or secondary element. So the fact that its use produced a self-starting motor without the aid of such excitation cannot alone serve to limit the invention to that effect, and I find no such limitation in the terms of the patent. The quotations from the arguments of counsel and experts for the complainant in prior cases, urging the distinction of this self-starting effect in reference to the application of the generic patents to non-synchronous motors, are without force in the present controversy, and it is unnecessary to ascertain their consistency or inconsistency with the interpretation sought on this hearing. Unless limitation to self-starting motors arises out of the prior art none can be imposed upon the claims in suit.

The further propositions urged by way of defence—aside from the defence founded upon prior inventions of the synchronous type to be considered—are these (1) that the synchronous motor of the defendant is the old generator of the art, simply reversed; and (2) that the Tesla invention is not present therein, because (as asserted) "the prepondering magnetization of the" direct current displaces and obliterates the "shifting alternating-current magnetization," or Tesla "whirling field of force." However specious both propositions appear on their face and in the argument, neither of them impresses me as controlling.

I believe that no proposition in the able and extended arguments on the part of the defence have been overlooked in my consideration of this case, although it has not seemed needful to discuss all of them for the purpose of this opinion. My conclusions are that the defendant's synchronous motor structure and operation are within the generic invention as patented, and expressly covered by the claims of Nos. 381,969 and 382,281; that the invention is utilized in the defendant's motor operation, notwithstanding the introduction of direct-current excitation to make it synchronous, in lieu of the full realization of the revolving field effect for self-starting; that such supplemental aid does not escape infringement, with or without advantage in such associations; and that, in any view the combination patents referred to are not limited to after-effect of the direct-current excitation, but apply to the defendant's combination. Decree will be entered accordingly as prayed in the bill.

ELEVATOR AND BOILER DEFECTS as reported to the Fidelity & Casualty [insurance] Co. by the company's inspectors during the year 1904 are summarized as follows in the "Monthly Bulletin" for March:

Boilers.		
Visits of inspection		58,039
Internal inspections		31,886
External inspections		77,805
Defects:		
Defective pressure gages	293	
" settings	1,261	
" riveting	238	
" water gages	398	
" and unprotected blow-off pipes	933	
" feed pipes	330	
" heads	121	
" patches	225	
" safety valves	381	
" mud drums	118	
Overloaded safety valves	113	
Safety valves of insufficient area	75	
Stop valves between boilers and safety valves	25	
Internal corrosion and pitting	1,658	
External corrosion and pitting	279	
Cases of deposit and sediment	420	
Cases of scale and incrustation	2,893	
Bracing insufficient	71	
Broken and loose stays and braces	290	
Furnaces out of shape	801	
Burned plates	68	
Blistered plates	89	
Bagged plates	1,109	
Cracked plates	610	
Serious leakage at the tube ends	989	
Serious leakage at seams	820	
Boilers without pressure gages	26	
Boilers without water gages	7	
Unclassified defects	747	
Total		15,418

Elevators.		
Visits of inspection		27,412
Number of elevators inspected		30,442
Defects:		
Defective worm shafts	78	
" cars	88	
" overhead work	76	
" guides and posts	185	
" guide shoes and springs	204	
" safety devices	329	
" operating devices	104	
" governor ropes	175	
" safety governors	110	
" hand cables	1,011	
" hand chains	46	
" lifting cables	803	
" lifting chains	21	
" counterweight cables	790	
" and broken sheaves	461	
" gears (worm and square)	101	
" door locks	723	
" enclosures	930	
" automatic stops	276	
" magnet brushes	29	
" electric motors	48	
" insulation	39	
" commutators	46	
" rheostats	58	
" keys	61	
" machine brakes	298	
" valve racks and pinions	49	
" pumps	15	
" engines	56	
" cable drums	66	
" cylinders and valves	191	
" piston rods	186	
" belts	114	
" chain and cable connections	60	
Leaky cylinders and valves	92	
Unguarded approaches at landings	175	
Missing clamps on lifting rods of counterweights	105	
Counterweight cables not properly connected	6	
Passenger elevators not provided with safety-speed governors and all of their attachments	17	
Minor adjustments	794	
Total		9,016

THE SNAG AND DREDGE BOAT "FLORIDA," for the government inland waterway work in the State of Florida, was completed at the yards of the Merrill-Stevens Co., Jacksonville, Fla., during the past month. This vessel is intended to replace the wooden snag-boat "Suwanee," which has been in service since 1888. The "Florida" is built of steel and is equipped for very varied service: snagging, hydraulic dredging, bucket dredging, hoisting and handling blasted or dredged material, etc. The hull is 131 ft. long, 28 ft. in beam and 7 ft. deep, drawing 4½ ft. loaded. The deck is crowned 4 ins. and has a sheer of 1 ft. forward and 6 ins. aft. Frames are spaced 18 ins., and are made of 3½ × 3-in. angles, which are strengthened by reverse frames of 2½ × 2½-in. angles to the turn of the bilge. Five transverse and one longitudinal watertight bulkheads are fitted. The hull plating is 5/16-in. thick at the bow, and ¼-in. over the remainder, except that the keel-strake, bilge-strakes, sheer-plates and center deck strakes are 5/16-in. Four spud wells extend through the hold. The boat is a stern-wheeler. The power is furnished by two 15 × 66-in. engines, taking steam from two internal-furnace boilers 8 × 14½ ft., at 115 lbs. per sq. in. working pressure. The stern wheel is 18 ft. in diameter by 16 ft. long. It has four sets of arms, 14 arms in a set. The buckets are 24 ins. wide × 2 ins.

thick, and are inclined to the axis in opposite directions on the two half lengths, like a "herringbone" gear.

The main hoisting engine, a double 14 x 18-in. reversing engine, is in the second compartment of the hold. A countershaft carrying the forward spud drums is geared from the main hoisting drum shaft, and in turn is bevel-geared to a pair of capstans on deck. A snagging drum is geared from the countershaft. The after hoisting engine is a double 8 x 10-in. reversing engine similarly fitted with drums and countershaft. It is in the fourth compartment of the hold. An independent steam-driven capstan is located on deck above this hoist.

Over the first bulkhead is an A-frame derrick with A-frame 36½ ft. high, and 45-ft. boom made of four 5 x 5 x ½-in. angles balloon-braced. The three sheaves at the head of the boom are 30 ins. in diameter, grooved for ⅞-in. steel rope. Two similar sheaves are suspended from the center pin for the bucket dredging ropes. The boom can be unstepped by a small auxiliary derrick stepped on the cross-beam of the A-frame. A triangular frame, stowed knocked-down, can be quickly put in its place for hydraulic dredging, stepped in the same casting in which the foot of the boom rests. A swivel bend forming part of the suction pipe is attached to this same casting. The outer end of the suction pipe carries a drag which holds the mouth of the pipe against the material in the proper direction whichever way the swing frame is moved. The dredging pump is an enclosed-runner centrifugal pump with 12-in. suction and discharge pipes, and is driven by a 12 and 20-in. by 12-in. engine on the same bed-plate. The clam-shell bucket is of 2 cu. yds. capacity.

The two spuds on the port side move in vertical wells, while the two starboard spuds can be inclined in a vertical longitudinal plane; this allows moving forward a fixed distance, the actual motion being produced by the stern-wheel and controlled by stops against which the starboard spuds come to bearing. For holding the boat in place, all four spuds are set vertical.

Special equipment comprises: A direct driven electric generator, 110-volt, 15-KW., operating an 18-in. searchlight, two arc lights, two 32-c. p. incandescent side lights and 70 16-c.p. incandescent lamps; the fixtures are combination oil and electric. A refrigerating plant with capacity of 600 lbs. of ice in 24 hours. An evaporator with a capacity of 2,000 gallons in 24 hours. A duplex fire pump capable of delivering 100 gallons per minute against 125 lbs. pressure. Six water storage tanks, 4 ft. in diameter by 8 ft. long. The equipment of evaporator and water tanks and the abundant coal-bunker capacity is designed specially with a view to enabling the boat to make coast trips from one port or river entrance to another.

PERSONAL.

Mr. James A. Omberg, Jr., Assoc. M. Am. Soc. C. E., has been reappointed City Engineer of Memphis, Tenn.

Mr. John E. Waller has been appointed County Surveyor of Terrill County, Georgia, succeeding Mr. J. S. Spear, resigned.

Mr. W. B. Groves, of Shreveport, La., has been appointed Manager and Superintendent of the municipal water and light plant of Prescott, Ark.

Mr. R. C. Satley has been appointed Division Engineer of the Chicago & Northwestern R. R., with headquarters at Winona, Minn, succeeding Mr. W. Beahan, resigned.

Mr. R. L. Langtim, formerly Mechanical Engineer of the Denver & Rio Grande R. R., has been appointed Mechanical Engineer of the Cincinnati, Hamilton & Dayton Ry., with headquarters at Lima, O.

Mr. Willard A. Smith, President of "The Railway and Engineering Review," of Chicago, Ill., who was Director of Transportation Exhibits during the Louisiana Purchase Exposition, has had conferred upon him by the German Emperor the decoration of officer of the Royal Order of the Crown.

Captain E. Barnardiston, Head of the Railroad Department of the Royal Engineers for the English Government, is now in this country for the purpose of making a study of the railroads and the conditions surrounding them.

Mr. Fred. Lavis has resigned his position with Westinghouse, Church, Kerr & Co. to accept an appointment as Resident Engineer with the New York, Westchester & Boston R. R., with headquarters at Mt. Vernon, N. Y.

Mr. James A. Green has resigned his position as Assistant State Engineer of Nebraska to accept a position as Chief Engineer and Manager of the Culbertson Irrigation Ditch. Mr. George Bates, of Lincoln, Neb., succeeds Mr. Green.

Mr. R. P. Johnston has been appointed Superintendent of Construction in the Electrification Zone of the New York Central & Hudson River R. R. south of Croton and North White Plains, with headquarters at the Grand Central Palace, New York City.

Mr. Geo. O. Sanford has severed his connection as Assistant Engineer with the Metropolitan Water and Sewerage Board of Massachusetts and has accepted a position with the U. S. Geological Survey in the Reclamation Service. Mr. Sanford has been assigned to the North Dakota irrigation projects and is now located at Williston, N. Dak.

At the regular annual meeting of the stockholders of the Apex Equipment Co., at its New York office, 11 Broadway, the following officers and directors were chosen: Willard U. Taylor, President; Clifton B. Jordan, Vice-President and Secretary; J. Sterling Drake, Treasurer and General Manager. Mr. M. C. Davis, heretofore General Manager, is no longer in the employ of the company.

Mr. Willard Beahan, M. Am. Soc. C. E., heretofore Division Engineer of the Chicago & Northwestern Ry., at Winona, Minn., has been appointed Principal Assistant Engineer of the Lake Shore & Michigan Southern Ry., with headquarters at Cleveland, O. He is succeeded by Mr. R. C. Sattley, formerly Foreman of Bridges and Buildings of the Chicago & Northwestern Ry., at Chicago, Ill.

Mr. Thomas W. Wilson, Assoc. M. Am. Soc. C. E., Chief Engineer of the International Ry. Co., of Buffalo, N. Y., has been appointed General Manager of that company to succeed Mr. T. E. Mitten, who has become associated with the Chicago City Ry. Co., as Vice-President. Mr. Wilson, who is a graduate of Lehigh University, class of 1890, came to Buffalo in 1899 as Chief Engineer for the Buffalo Street Ry. and Suburban system.

Mr. Francis Lee Stuart, M. Am. Soc. C. E., formerly Engineer of Surveys for the Baltimore & Ohio R. R., has been appointed Chief Engineer of the Erie R. R. Mr. Harry R. Talcott, hitherto Assistant Engineer of the Baltimore & Ohio R. R., at Cumberland, Md., succeeds Mr. Stuart. Mr. W. L. Derr, who has been Acting Chief Engineer of the Erie, has been appointed Superintendent of the Susquehanna Division of that road.

Mr. George C. Warren, heretofore Vice-President and General Manager of Warren Brothers Co., of Boston, Mass., has been appointed President of that company, to fill the vacancy caused by the death of Frederick J. Warren. Mr. Walter B. Warren, formerly Assistant General Manager has been appointed General Manager. The other officers of the company remain unchanged and are as follows: Mr. J. M. Head, Vice-President and General Counsel; Mr. Albert C. Warren, Treasurer; Mr. Ralph L. Warren, Secretary; Mr. Charles O. Warren, General Superintendent.

Mr. Lee Treadwell, M. Am. Soc. C. E., has become associated with The Foundation Co., of 35 Nassau St., New York, and will be Superintendent in active charge of their work in connection with the Terminals of the Frisco Road at Chalmette, near New Orleans. This work, with other western work, will be under the general supervision of Mr. George Adgate, M. Am. Soc. C. E., Western Manager for The Foundation Co. Mr. Treadwell has just completed at Portsmouth, N. H., the large granite dry dock for the U. S. Government, for which John Peirce was the contractor, and of which Mr. Treadwell was the Resident Superintendent in active charge.

Mr. L. C. Fritch, M. Am. Soc. C. E., has been appointed Assistant General Manager of the Illinois Central Ry. He entered the engineering department of the Ohio & Mississippi Ry. in 1884, and in 1892 was appointed Engineer of Maintenance of Way. In November, 1893, he was appointed Division Engineer of the Baltimore & Ohio Southwestern Ry. (which absorbed the Ohio & Mississippi Ry.), and in September, 1899, he was appointed Superintendent of the Mississippi Division of this railway. In February, 1904, he entered the service of the Illinois Central Ry., being engaged in special work for the Assistant General Manager. He has been Secretary of the American Railway Engineering & Maintenance of Way Association since its organization.

Obituary.

Roland C. Luther, M. Am. Inst. Min. Engrs., Second Vice-President of the Philadelphia & Reading Coal & Iron Co., died March 6 at his home in Pottsville, Pa. Mr. Luther became Mining Engineer of the Philadelphia & Reading Co. in 1882, and in 1888 he was promoted to the position of General Superintendent. Subsequently he became Second Vice-President of the Company. From 1875 to 1882 he was engaged in engineering work in the West, principally in Nevada. He was 59 years old.

Richard Somers Hayes, formerly President of the St. Paul & Duluth R. R., died March 2 at his home in New York City. Mr. Hayes was born in Philadelphia and was graduated from the Civil Engineering Department of the University of Pennsylvania. Immediately after his graduation he went to Texas and for many years he was prominently identified with railroads of that state. He was Engineer of Construction of the Texas & Pacific R. R., and was also the Receiver of the Texas International, becoming president of that road when the receivership was dissolved. He was 59 years old.

Burr Bassell, M. Am. Soc. C. E., died suddenly of spinal meningitis, Feb. 25, at his home in Los Angeles, Cal. Mr. Bassell was born in Upshur County, West Virginia, in 1858, and was graduated from Washington and Jefferson College in the class of '81. He went to California in 1887 and for some time thereafter was Assistant City Engineer of Los Angeles. In 1891 and 1892 he acted as Assistant Chief Engineer for the Arrowhead Springs Co., of San Bernardino, Cal., and after this he was connected for a period of three years with the building of the Tabeaud Dam in Northern California. For the past three years he has been Resident Engineer of the Kern River Co. Mr. Bassell had recently received an appointment as Resident Engineer for a $2,000,000 hydraulic dam enterprise at Wichita Falls, Tex., for which J. D. Schuyler, M. Am. Soc. C. E., is Engineer, and he and his family were making preparations to go to that place when he was stricken with his fatal illness. Mr. Bassell had made a specialty of hydraulic and dam construction work, and was the author of a book, entitled "Earth Dams," which has just been brought out by the Engineering News Publishing Co. He was also a contributor to various scientific and mechanical publications.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21, 22, 23. Annual meeting at Chicago. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committeee, W. F. Allen, 24 Park Place, New York.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the society's rooms in Chicago on March 1, the Secretary read a paper by Mr. D. W. Mead on "The Recent Improvements of the Plant of the Danville Water Co." These improvements were described in our issue of April 28, 1904.

ENGINEERS' CLUB OF CINCINNATI.—The regular meeting for March will be held at the rooms of the Literary Club, 25 E. Eighth St., Cincinnati, O., on Thursday, March 16, at 8 p. m. Mr. F. E. Morris will read a paper on "Reinforcing the North Abutment of Ludlow Ave. Bridge with concrete and piling, after settlement of old limestone masonry and failure of wing-walls." A general discussion of the subject of foundations is expected to follow. Secy., C. H. Meeds.

MONTANA SOCIETY OF ENGINEERS.—The February meeting of the society was held in the society's quarters, No. 16 Leyson Block, on Saturday evening, February 11, 1905, with President King presiding, and a large membership in attendance. Mr. Joseph H. Harper presented his views on the proposed changes in U. S. Mining Laws in a written paper, and at the close of his remarks a lengthy discussion on part of a majority of the members present followed. It was decided that a continuation of the subject of mining law changes and legislation be made the leading topic for the March meeting, to be held on March 11, 1905, at 8 p. m. Secy., Clinton H. Moore.

WESTERN RAILWAY CLUB.—At the meeting held Feb. 21 at the Auditorium Hotel, Chicago, the 21st anniversary of the club was celebrated by a reception to the past presidents. The present president, Mr. Le Grand Parish, was in the chair, and ten past presidents were in attendance; six others were unable to attend and three are dead. Brief addresses were made, and a resolution was passed electing the past presidents as life members.

The meeting was unusually large, about 400 persons being present. At the close it was suggested that an endeavor should be made to bring in more members from the transportation and engineering or maintenance of way departments, as the majority of the members now represent the mechanical department of railway service.

AMERICAN ELECTROCHEMICAL SOCIETY.—A preliminary compilation of the program for the coming annual meeting of the society has been prepared. The following named technical papers are expected: "The Interdependence of Atomic Weights and Electrochemical Equivalents," by Mr. A. Reuterdahl; "An Optical Method of Observing Diffusion in an Electrolyte," by Mr. C. Hambuechen; "The Micro-structure of Silicon and Silicon Alloys," by Mr. A. B. Albro; "Osmosis," by Prof. L. Kahlenberg; "The Electrolytic Precipitation of Chromium," by Prof. H. R. Carveth; "Conduction in Electrolytes," by Prof. J. W. Richards; "The Migration and Coagulation of Colloidal Suspensions," by Prof. J. C. Blake; "Water Powers of the Canadian Hinterland," by Mr. C. G. Richardson; "The Electrodeposition of Silver," and "The Adherence of Nickel to Nickel." by Mr. R. C. Snowdon; "Treating Low-grade Ores and Tailings by Electrolysis," by Mr. E. Fahrig; "Removing Solvents during Electrolysis," by Mr. C. Hering; "The Reduction of Titaniferous Ores into Steel and Titanate of Iron," "The Reduction of Different Oxides of Lead by Electric Current," and "The Electrodeposition of Metals on Aluminum," by Mr. A. Lodyguine; "Billitzer's Method of Determining Absolute Potentials," by Mr. H. M. Goodwin; "A Low-Voltage Standard Cell," by Mr. G. A. Hulett.

An exhibit of electrochemical apparatus and the like will form a feature of the meeting. Prof. W. H. Walker of the Massachusetts Institute of Technology, Boston, Mass., is in charge of the preparations for this exhibit. Correspondence on other features of the meeting should be addressed to the secretary, S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

In this Issue.—Engineering Literature Supplement. Prize Offer for Papers on Concrete Blocks.

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A NOTE ON EARLY AMERICAN SUSPENSION BRIDGES.

As the result of a late rummaging among old books, the following notes are presented as being not without interest in fixing as definitely as possible the claims of certain inventors in connection with the first introduction of suspension bridges.

Crude suspension bridges of vines, ropes or even chains had been used by the Indians of South America and the Chinese from time immemorial. But these bridges carried the footway directly on the catenary and they were practically without design. In 1741 a very crude chain bridge, 70 ft. long and 2 ft. wide, was built over the River Tees in England, but from all that is now known concerning it, this early English suspension bridge was but a slight advance upon the Indian and Chinese structures.

The first man to apply scientific design to a suspension bridge was the American engineer, James Finley, of Fayette Co., Penna. In 1796 Finley built one of his iron chain bridges across Jacob's Creek, in the State of Pennsylvania, on the turnpike connecting Uniontown and Greenburg. Finley proposed for his bridges substantial masonry towers; the use of two main suspending members built up of iron links, each as long as one of the panels; a deflection in the cables equal to one-seventh of the span; the floor suspended by rods and stirrups located at the panel points; and to overcome any tendency to overturn the main towers, he would give the same deflection to the shore half span as to the main span. He also insisted upon longitudnial stiffness in his floor system, and provided for this in his specifications as follows:

> To bind and connect the whole, that they have the same effect as a platform of one piece, four or more joists will be necessary for the upper tier, to extend from end to end of the bridge; each will consist of more than one piece, the pieces had best pass each other side by side, so that the ends may rest on different joists on the lower tier. The splice will then extend from one joist to another of the lower tier and must be bolted together by one bolt at each end of the splice. The planking floor is laid on the upper tier.

This method of stiffening the floor was sufficient for the spans and loads in use at that time, and in connection with a stiff hand-railing it fulfilled the requirements of the existing traffic. But few bridge-builders understood Finley's line of reasoning, and a number of bridges nominally built after his plan failed through neglect to carry out his advice. Believing that unnecessary weight and cost were entailed, builders cut down the continuous longitudinal stiffening beams, failed to proportion the loads to the span, and some used cable deflections equal to only one-fifteenth of the span.

Up to 1801, when Finley patented his design, eight bridges had been built on his plan in the United States, and between 1800 and 1808 forty more were constructed. The largest of these was the bridge built across the Schuylkill, near Philadelphia, with a span of 306 ft. The Potomac bridge, near Washington, had a span of 130 ft., with a floor 15 ft. wide; the Cumberland bridge, in Maryland, had the same span; the bridge over Brandywine Creek, near Wilmington, Del., had a span of 145 ft., with a floor 30 ft. wide; and two other bridges were built of 120 ft. span each, at Brownsville, Fayette Co., Pa. The bridge across the Merrimac, about three miles from Newburyport, Mass., was built on Finley's design by John Templeman, of the District of Columbia, and was specially noted at the time as one of the most interesting structures of its type in the United States. This bridge had a span of 244 ft.; the masonry towers were 47 ft. wide and 37 ft. high above the bridge floor; the two roadways, each 15 ft. wide, were supposed to be safe for horses and carriages at any speed. Ten chains, each 576 ft. long, were used; three located on each side of the bridge and four in the middle; they were designed to be safe for a load of 500 tons. The railing was stout, and "contributed much to the stiffness of the floor;" and there was said to be "very little perceptible motion, whatever the speed of any kind of traffic."

CHAIN SUSPENSION BRIDGE, FALLS OF SCHUYLKILL.
(From Painting by Thomas Birch.)

The bridge built over the Lehigh River in 1811, near Northampton, Pa., was made up of two whole and two half-spans, 475 ft. long in all. It carried two roadways and two 6 ft. footways, and is the first suspension bridge on record having more than one span.

While Finley's bridges were built with long iron links, the application of wire to a suspension bridge was also of American origin. Two chain bridges built at the Falls of Schuylkill, near Philadelphia, had been destroyed; one by a rush of cattle over the bridge, and the other broke down under the weight of snow and ice. The second bridge failed on Jan. 17, 1816, and as a substitute for it the nearby wire manufacturers, White & Hazard, built a wire suspension footbridge, which was opened to traffic in June, 1816. This bridge had a span of 408 ft., and the floor was 18 ins. wide. It was described in the U. S. Gazette, of Philadelphia, as "a new piece of mechanism for the conveyance of foot-passengers across a river." A crude view of this bridge was published in the Massachusetts Magazine, Vol. IV., which is here reproduced. But, as described at the time, the bridge was more nearly a true suspension bridge than is here represented. The main cables passed from the upper windows of White & Hazard's shop to large trees on the other bank, and the floor system was carried by suspenders connected to the two cables. The bridge was only considered safe for eight foot-passengers at one time; but a contemporary says that he has seen "thirty people upon it at one time, including rude boys, who ran backward and forward." The entire cost of the bridge is said to have been $125.

As the first European wire suspension bridge was built at Fribourg, in Switzerland, in 1834, the Schuylkill wire bridge of 1816 antedates it by 18 years. The English engineer, Sir Samuel Brown, built an iron suspension bridge over the River Tweed in 1819, with a span of 449 ft. This bridge is described as supported by "cables," but the available data does not say how these cables were constructed.

As interesting in this connection, we reproduce from an old engraving a contemporaneous view of Finley's patent chain-bridge. With it is also given an original estimate for a proposed Finley chain-bridge across the Susquehanna River. The boldness of the proposition, with its length of 5,600 ft., and the then high cost of such a bridge, sufficiently explains why it was not built. Judging from the span given, this bridge was intended to be built at Columbia, Pa., a point later spanned by a wooden Burr-truss bridge.

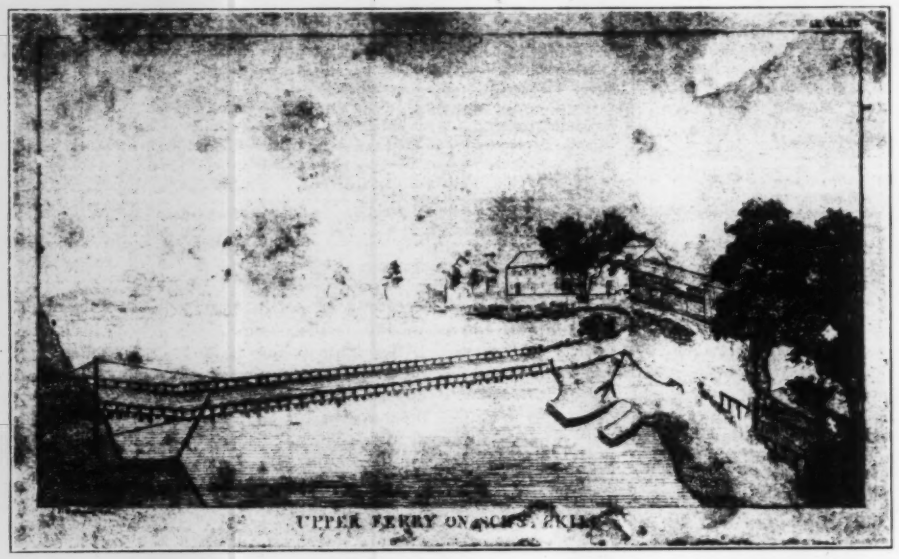
For much of the information here used—especially for that part relating to the detail of the Finley bridges constructed, we are indebted to Miss Ella M. Hess, of Merrick, Long Island.

Since writing the above we have found a photograph of a painting of the first chain-bridge at the Falls of Schuylkill made by the well-known American artist, Thomas Birch. This picture shows the construction of the bridge better than the usual painting, and is topographically very accurate. The history of these chain bridges is given practically as follows in Westcott's History of Philadelphia.

On April 8, 1807, the Pennsylvania Legislature passed an Act granting to Robert Kennedy—a tavern-keeper at the Falls of Schuylkill, a right to

use the water-power at that place, provided that he would build locks to accommodate the passing of boats. Kennedy secured the passage of this Act with the view of encouraging the erection of mills at this point; but in this intention he failed.

At the next session of the Legislature, Robert Kennedy and Conrad Carpenter applied for authority to erect a bridge at the Falls of Schuylkill, and on Feb. 22, 1808, such authority was given them coupled with the privilege of collecting tolls.



WIRE SUSPENSION BRIDGE OF 400-FT. SPAN AT FALLS OF SCHUYLKILL, NEAR PHILADELPHIA.
Built in June, 1816, by White and Hazard.

The money necessary was soon raised by subscription, and work was commenced. The eastern abutment was so arranged as to protect the mill site of Mr. Kennedy; and the latter later sold the mill-right to Josiah White and Erskine Hazard, who there erected a rolling-mill and subsequently added to this a mill for making wire. The bridge erected was called the "Chain Bridge," and it had two main piers and two shore piers or abutments, the two main spans being 153 ft. long each. The description fails to enter further into the details of its construction. This bridge was finished in 1809; but it broke down in 1811 under the weight and impact of a drove of cattle passing over it.

Steps were at once taken to rebuild the bridge. On April 2, 1811, an Act was passed incorporating the Schuylkill Falls Bridge Company, and to this new company Kennedy and Carpenter transferred all the rights and privileges granted them in the Act of Feb. 22, 1808. Under the new Act the following prominent citizens of Philadelphia and its immediate neighborhood were named as the President and Managers of the company—Robert Kennedy, Paul Cox, Samuel Wheeler, John Johnson, Algernon Roberts, Thomas McEwen, John Thorburn, Walter Franklin, Francis Johnson, Reading Howell and William T. Donaldson.

It is not stated who designed the first chain-bridge at the Falls; but that the first was not built in full accord with the system suggested by James Finley is shown by Finley's severe criticism of this plan—in the "Port Folio" of Jan. 17, 1811, in which he says that the bridge failed by reason of the breaking of an insufficient and badly designed coupling member.

The second chain-bridge at the Falls also fell down—on Jan. 17, 1816, as the result of an accumulation of snow and ice upon the floor. As previously stated, White & Hazard then temporarily spanned the river at this place with a light wire-suspension bridge, opened to traffic in June, 1816. In January, 1817, an Act was passed by the Legislature authorizing the Schuylkill Falls Bridge Company to sell all its corporate rights to certain persons "who will undertake to erect a permanent bridge" at this point. The third bridge here was designed by Louis Wernwag and was built by Isaac Nathans, and was opened in December, 1817. This later bridge was a wooden arched truss, following the general design of the Wernwag bridges, and it stood for a number of years.

COMMERCIAL POSSIBILITIES OF BLAST FURNACE GAS FOR THE DEVELOPMENT OF ELECTRIC POWER.*

By F. Du P. Thomson.†

Not until the Lackawanna Steel Company decided upon the use of gas engines for the development of electric power and for the compression of the blast with gas obtained from the blast furnace itself, did any iron manufacturer in this country take the initiative and install even a trial engine constructed for this special class of service. To those European iron masters who have demonstrated the feasibility of the system we are indebted for a long step forward in blast furnace economy, a step which has made possible the development of fully 1,000,000 HP. over and above the requirements of the blast furnaces themselves, when the output of this country is taken as 20,000,000 tons of iron per year. Despite discouraging reports as to the results of European installations, made by American investigators, the blast furnace gas engine industry continues to grow.

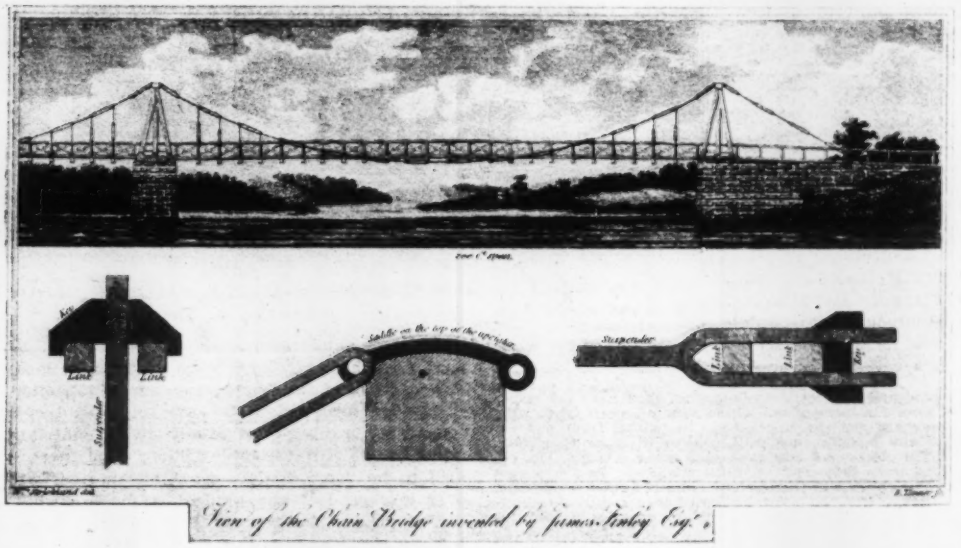
When the first installation was made at Buffalo, great activity prevailed in the iron trade. During the years 1899 to 1903 the volume of business was so great and prices so remunerative as to give no good reason to consider the expense of replacing equipment which answered the purpose, for money employed as working capital yielded greater returns than if invested in equipment which might be operated with greater economy than that in existence. With business on somewhat closer margins and the present necessity of replacing or supplementing plant, consideration of gas engines using blast furnace gas is more serious.

Competition has sprung up also in the manufacture of large gas engines. The performance and detail construction of the engines offered for sale to-day is subjected to much closer scrutiny than usual in the purchase of steam engines for the same duty. At present there are in the country no less than six firms, to my knowledge, who will undertake to furnish gas engines in sizes varying between 2,000 HP. and 3,000 HP.

A profitable market for power is essential before we may consider at all the use of surplus blast furnace gas for the development of power. Without such a market, the replacement of steam blowing engines by gas-driven blowing engines, in order to make a larger surplus available, should not, at present prices for equipment, be considered. If, for example, a blast furnace plant is not operated in connection with steel works nor in the vicinity of works which do or may use large quantities of power, no use could be found for the surplus gas which would be made available by the installation of gas blowing engines. In such a case, there would be no good grounds for recommending gas engine blowing equipment, unless the costs were less than that of the equivalent steam blowing equipment, including boilers. If, however, a market is within economical transmission distance, and other conditions are not prohibitive, very satisfactory returns may be expected.

An important and, in most cases, essential condition with which a power plant must comply, is that of uninterrupted service. The power plant which we consider here depends for its supply of gas upon the blast furnace, the heir to many ills. It may be put out of blast because the lining is worn out, or banked because there is a shortage of coke or other raw material, or it may be banked or put out of blast because of trade conditions, or on account of labor troubles, or there may be a stoppage of greater or less duration due to accident or trouble in the working of the furnace, and in its regular operation as well, the result of which is a suspension of its function as gas producer. To secure, within a reasonable degree of certainty, a continuity of supply, no group of less than three blast furnaces can be considered as available to supply a power plant, which is intended to produce power for the general market. At any group of furnaces at least one will at some time be out of blast for relining, and at least one other furnace may be stopped for some one of the other reasons given above. With a group of three blast furnaces, therefore, the surplus gas of one will always be available. With groups of more than three, still greater security against interruption will result, if we assume one furnace out of blast and two temporarily stopped. To be even more conservative, two furnaces might be assumed as out of blast for relining at the same time, but with a power plant dependent upon the blast furnace plant, repairs of this kind can be so timed that it will not be necessary to reline two furnaces at once.

The value of a large number of units to obtain a given output of iron is very evident, if the development of a large percentage of the surplus gas into power is to be made possible. Increased cost of construction and operation of a blast furnace plant made up of a number of small units, as compared with the same items of expense for a plant of the same capacity made up of large units must be more than balanced by the profits which are to be realized from the operation of the larger power plant. Further than this, the prices obtained for the power must warrant the continuance in blast of all but one furnace of a blast furnace plant, when trade conditions would imperatively dictate a suspension of operation. The profit must at least pay the interest on the labor and material invested in manufacturing periods in which there is no market for the product, and at least part of the loss due to a falling market.



FINLEY'S CHAIN SUSPENSION BRIDGE.
(From an old print.)

*From the "Electrochemical and Metallurgical Industry," March, 1905.

†Lackawanna Iron & Steel Co., Buffalo, N. Y.

With proper foresight in location and intelligent design we can eliminate from water-power plants every probable cause for a suspension. The labor question enters into it only to a very small degree. It looms up larger in the steam and gas producer power plants, owing to their dependence upon a supply of coal, into which the labor element of mining and transportation enter. The blast furnace gas power plant, however, is burdened with the responsibility of maintaining operations in spite of trouble which may occur at ore, stone and coal mines, coke ovens, along the lines of transportation, and finally at the blast furnace plant itself. Nor is this minimized to any great extent by the large stock carried in the furnace yards, for the troubles may occur at the end of the winter when stocks are low and no accurate estimate can be made as to how long the trouble may last. To meet such an emergency a gas producer plant might be installed, but even this would be only a partial remedy, and would involve an additional yearly charge for power of not less than $7.50 per HP. or $10 per KW., not including the cost of any coal which may be consumed by such a plant to maintain at least a portion of it in readiness, or that required during such periods that the blast furnaces are unable to supply gas.

Without wishing to discourage the idea of building commercial power plants in connection with blast furnace plants, I believe it better to point out as clearly as possible all the disadvantages in the first instance, and leave to the decision of the investor whether the possibilities, as I shall attempt to show them, sufficiently outweigh the disadvantages to encourage him to venture capital in this rather than some other undertaking.

The amount of surplus energy and the proportion available for the development of power are to be determined. The waste gases of the blast furnace contain about one-half of the total heat originally possessed by the fuel, and their value is approximately in direct proportion to the coke consumption per ton of iron. It has been variously estimated that from 18 to 33% of this heat is required to heat the blast. Not only have no accurate determinations ever been, to my knowledge, made of the gases consumed in hot blast stoves, but the heat which is to be imparted to the blast varies with local conditions, even when the final temperature is identical. The distance between engines and stoves, the size of mains, the efficiency of burners and of the heating apparatus itself, materially affect the heat consumption. Differences in blast furnace practice result in different pressures, and the range in temperatures employed is by no means inconsiderable. A conservative estimate of the percentage of the heat of the waste gases to heat the blast would be 30%. This would not, in general practice, be exceeded. The compression of the blast by steam engines giving an economy of 20 lbs. of steam per HP.-hr. when run condensing, under normal conditions, with boilers which convert 60 to 70% of the heat of the gas burnt into heat of steam, requires from 33 to 40% of the heat of the waste gases. For auxiliary purposes, such as pumps, light, power for hoists and ore-handling machinery, approximately 7 to 10% is required. By the substitution of gas-blowing engines and gas engines for the production of power for auxiliaries, the figures above may be reduced to read 16.5 to 20% and 3.5 to 5%, which, for clearness, are summarized in Table I.

The wide range of the surplus available under the head of steam engines is due principally to differences in efficiency of apparatus and only in a limited degree to differences in practice. The difference in surplus available under the head of gas engines depends almost entirely on differences in furnace practice, for the efficiency of the gas engine equipment is in each case the same. The maximum surplus with steam equipment is, curious to say, identical with the minimum to be expected with gas engine equipment.

The superiority of the gas engine over the steam engine may appear rather small, when the figures given in Table I. are compared with those frequently seen as the results of published tests. It must be remembered, however, that the gas blowing engine operates normally at only about two-thirds of the load which it must be designed to carry when the blast pressure reaches 25 lbs. to the square inch. Such periods of high pressure may be coincident with a poor quality of gas, making the conditions even worse than indicated above. The gas engine in such service is at a disadvantage compared with a steam engine, designed to operate with economy at normal load, with capacity, however, to supply air at the highest pressures met with in general practice.

TABLE I.

Proportion of Blast Furnace Gas Power Required by the Furnace Plant.

Use.	Steam Engines.		Gas Engines.	
Heating the blast	18 to 33%		18.0 to 33%	
Compressing the blast	33 to 40		16.5 to 20	
Auxiliaries	7 to 10		3.5 to 5	
Surplus available	42 to 17		52.0 to 42	
	100	100%	100	100%

Large gas engines are built to-day, which will, at full load, give a duty of 194,000,000 effective foot pounds, as compared with a duty of 82,000,000 effective foot pounds from one of the best steam engines, per 1,000,000 B. T. U. in the gas consumed in each case. As the economy of the gas blowing engine will approximate only 80% of the figure given above, it may readily be seen that its ultimate economy, in blowing engine practice, may be safely said not to exceed twice that of the steam engine.

The actual amount of power available from the surplus gas developed by gas engines will vary with the coke consumed per ton of iron and the efficiency of engine and load factor. The coke consumption per ton of iron may be within a comparatively short time reduced to an average figure of 1,700 lbs. as the result of the method which has recently been developed to remove the moisture from the blast. On the other hand, where the mixture is poor and other conditions unfavorable, the coke consumption may be as high as 2,800 lbs. per ton of iron. There will be present in the waste gases for the one case 9,000,000 B. T. U., and for the other, 18,000,000 B. T. U. per ton of iron. The average of present practice in coke consumption is probably very close to 2,240 lbs. per ton, yielding 14,000,000 B.T. U. in waste gases. We may reasonably expect a reduction of this figure to that of 1,700 lbs., as stated above, but, on the other hand, improvements in engine and stove economy, which are to be anticipated, may permit the use of the larger figure given in Table I. as the percentage of surplus gas available with gas engines. The amount of surplus heat available for power per ton of iron may, therefore, be taken as 52% of 9,000,000 B. T. U., or 4,680,000.

From this amount of heat it is possible to develop 468 HP. per ton of iron made per hour, with gas engines which have a thermal efficiency per effective horsepower of 25%, or can produce one effective horsepower per 10,000 B. T. U. per hour. Manufacturers of gas engines are willing to guarantee this result when their engines are operated at full load. For a blast furnace making 300 tons of iron per day, we may rely with certainty upon obtaining not less than

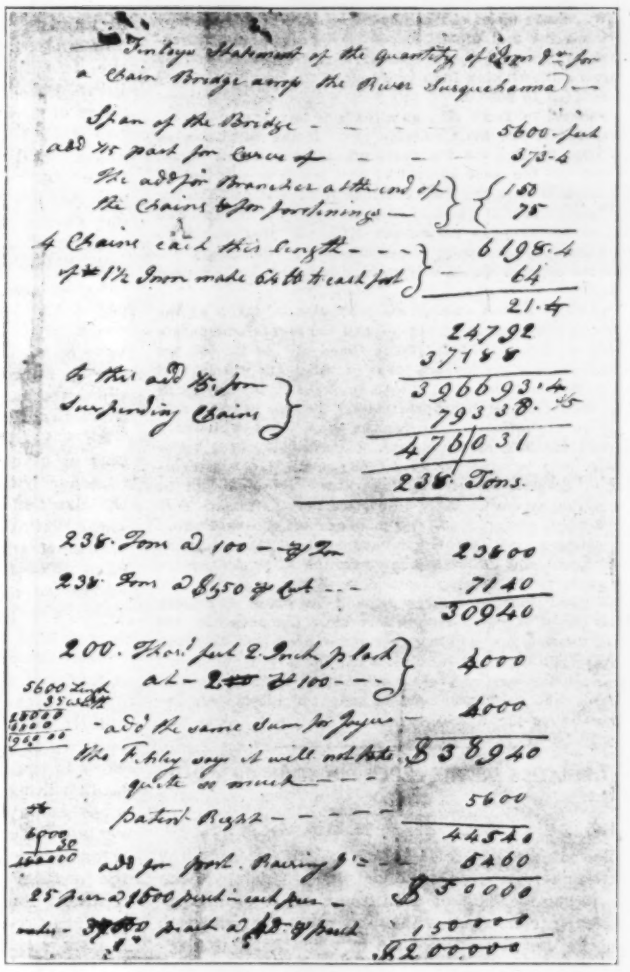
$$\frac{300 \text{ tons}}{24 \text{ hours}} \times 468 \text{ HP.} = 5{,}850 \text{ HP.}$$

or let us say 6,000 HP.

I shall not attempt to discuss here the details of engine construction nor any of the claims to excellence of the several makes of large gas engines, for these have been quite fully set forth in periodical literature, as well as the catalogues of the builders. The subject of gas cleaning, however, is of great importance and merits some attention at this point. It is now generally conceded that blast furnace gas must be cleaned before use in the gas engines, if for no other reason than that the cleaning process, at the same time, reduces its temperature and thus increases its density, thereby increasing the power available from a cylinder of given dimensions. Whether cleaned by transmission through great length of pipe at low velocity, or by contact with sprays or surfaces of water, the temperature is lowered. Cooling and cleaning by the dry or transmission method is not satisfactory, and becomes very costly if a temperature below 120° F. is desired. Nor do conditions of velocity, satisfactory for cooling, permit the settling of the dust, and the finest particles, when dry, require practically absolute rest, which is, of course, impossible. Water cooling and washing is now generally employed. Electrostatic methods of cleaning have been suggested and experimented with, but so far as I am informed no practical results have as yet been obtained. In any event the gas for gas engines must be cooled. Cooling not only increases the density of the gas itself, but removes by condensation the moisture which is brought over with the gases from the ore, limestone and coke, amounting to between 3 and 5% by volume, reducing the heating value of the gas to that extent. The temperature of the gas must be lowered as much as the temperature of the water available, and the quantity which it is practicable to use, will permit, so that the gas at this temperature, when saturated, shall not contain more moisture than previous to treatment.

Various means have been employed to produce an intimate mixture of the cooling water and the dust-bearing gas. At first the old coke scrubber of coal-gas works practice was used, consisting of a vertical pipe filled with coke, through which water trickled from above, and gas was made to pass from below. In order to overcome the resistance to the passage of the gas through the coke, either a steam jet blower or centrifugal fan was used. It was found that the dust adhered to the blades of the fan, and to avoid frequent stoppages for cleaning, water was introduced at the center of the fan to wash the dust away. Not only did this water keep the fan clean, but being dashed into fine particles by the action of the arm and blades, became intimately mixed with the gas and dust, reducing their temperature. The action of centrifugal force assisted also to separate the particles of water and moistened dust from the current of gas. The mixture of water and dust was very readily flushed out of the fan. We thus owe to accident the most effective form of gas washer that has yet been devised. Improvements have been made in details, making it more efficient, but in essentials the apparatus as first used remains to-day unchanged. More or less fine spray or mist of water is delivered by the fan with the gas and some form of separator, either of a type similar to steam separators and exhaust steam heads, or else a dryer in the form of a sawdust box is placed in the gas main between the fan and the engine to remove it. The presence of mist in the gas is objectionable, because it may accumulate in the gas mains, freeze in winter, or at any time it may be carried into the motor cylinder, cause difficulty in ignition, or absorb a certain quantity of latent heat when converted into steam by the combustion of the gas with which it is mixed.

The equipment of fans required and the consequent cost of power may be materially lessened by the introduction of pre-cooling devices, relying on the fans principally for the separation of the water and dust from the gas. These pre-coolers may take the form of horizontal pipes equipped with water sprays, or vertical pipes or towers similarly equipped and arranged so that the gas moves upward against the sprays. The gas in this way not only comes in contact with each successive spray, but the action of the drops of water, owing to the longer time which they are exposed to the gas in falling through it, reduces the temperature and moistens the dust much more effectively in a vertical than in a horizontal spray pipe. The action of the sprays, however, is to beat the gas back so that, as a matter of fact, the fan motors must exert some power to draw the gas through the towers. This fact is evidenced by an inflow of air through any opening at the top of the tower, where, if there were any of the pressure such as exists at the top of the blast furnace, there would be an outflow of gas. The expenditure of power to draw the gas through the tower is less than that required to accelerate the gas and water required for cooling in a fan, should the pre-cooling towers be omitted. The water consumption is approximately 0.06 gallons per HP. per minute, and the fan, motors and pumps take about 1.3% of the rated power of the gas engine installation which they serve.


Finley's Statement of the Quantity of Iron &c for
a Chain Bridge across the River Susquehanna
Span of the Bridge - - 5600 feet
add 7/8 part for Curve of - - 375.4
The add'l for Branches at the end of
the Chains & for Forgings - } 150
75
4 Chains each this length - - - } 6198.4
of 1½ Iron made 64 lb to each foot } 64
21.4
24792
37188
To this add ⅛ for
Suspending Chains } 396693.4
79338.
476031
238. Tons.
238. Tons @ 100 - ₰ Ton 23800
238 Tons @ 350 ₰ Ton - - - 7140
30940
200. Thousd feet 2 Inch ₰ Block
at - 2 ₰ @ 100 - - } 4000
5600 Feet
35 Cables
- add the same sum for Ropes - 4000
The Finley says it will not take 38940
quite so much - - -
Patent Right - - - - - 5600
44540
add for Work. Bearings &c - 5460
25 Men @ 1500 Pounds each Men - 50000
Anchors - 30000 Pounds @ 2½ ₰ Pound 150000
200000

FAC-SIMILE OF AN OLD ESTIMATE OF THE COST OF A FINLEY SUSPENSION BRIDGE 5,600 FT. LONG TO CROSS THE SUSQUEHANNA RIVER.

The degree of purity necessary will depend to some extent upon the type of engine in which it is to be used. The two-cycle gas engine equipped with gas pumps provided with piston valves must be supplied with purer gas than four-cycle engines which take their supply through the motor cylinder only. Entire exemption from troubles incident to the presence of dust in the gas may be avoided, if the purity is so high that the gas contains no more than 0.025 grams per cubic meter. A very simple apparatus has been devised, which has made possible accurate and rapid determinations of the quantity of dust present in the gas. It is highly important to determine the quantity and character of the dust, and to study carefully in each case all the local conditions before any attempt is made to design a gas-washing plant.

Any variation in the composition of the gas affects, to some extent, the regulation. Especially is this true when this change in composition consists in a sudden increase in the percentage of hydrogen, due to a leak in some cooling device which permits water to enter the furnace. At present there are no means known by which the power plant may be warned of its approach in the current of gas. By means of the composimeter changes in the calorific value of the gas, other than those due to hydrogen, are at all times indicated, and the power house would in most cases have time to start up a reserve unit when the calorific value of the gas falls to a point below which the full power of the engine cannot be developed.

Without uniformity of gas pressure, regulation sufficiently close to insure successful operation in parallel of alternating-current generators, is extremely difficult, if not impossible. The use of a gas holder affords a simple means of maintaining a constant pressure, and provides some little storage room as well. Changes in the operation of the blast furnace and variations in the consumption of gas by the engines are too frequent and rapid to permit at present of any satisfactory method of regulation at the fan. The cost of the gas holder of sufficient capacity to maintain even for one hour a supply of gas for the plant at full load, when all the blast furnaces are stopped, would not, except in special cases, be warranted and in general the use of a large gas holder is unnecessary.

In order to give the power proposition every benefit possible, we shall consider only the largest units at present obtainable. I have elsewhere stated that builders are prepared to furnish and guarantee the successful operation of gas engines ranging between 2,000 and 3,000 HP. per unit.

The cost of plant and cost of power must be based on certain assumed conditions of service and load factor. We will assume, for example, that the character of the service which the power plant is to supply will involve suddenly applied (though possible momentary) overloads of 50% and that the load factor is 50%. As the gas engine has no overload capacity (or, stated differently, we may say that full load is the limit of its overload capacity), the nominal full rated load must be two-thirds of the actual full load capacity, for the case which has been assumed. A gas engine of 2,000 Eff. HP., coupled to a 1,000 KW. generator capable of momentary overloading to 50%, would be a suitable combination. This class of service and type of unit will be designated as Class "A."

For service in which there is never any overload, or where the full load of the generator is but 80% of the engine capacity and the generator overload never exceeds 25% a 2,000 Eff. HP. gas engine coupled to a generator of 1,500 KW. would be a satisfactory unit, and we may designate this type and service as Class "B."

In either class the space occupied would practically be the same and require for each unit a length of 50 ft. in a building 75 ft. wide, together with some additional length to house the compressors, pumps and exciters which go to complete the installation. No proposition except one which utilizes all the surplus gas upon which we can depend need be considered here. Nor shall we consider blast furnaces producing less than 300 tons per day each; but this must not be taken to preclude consideration, except in this particular case, of such a project for a group of smaller blast furnaces. The estimate here given is on a power plant in connection with a group of either three or four 300-ton furnaces, in which the surplus gas from one furnace only may be utilized.

Tables II. and III. give in detail the estimated cost of installation and cost of power at the switchboard, and are based on actual experience which the writer has had in the construction of such plants. Sufficient allowance has been made to insure against variation in price and efficiency of labor and cost of materials. In Table III. the annual amounts have been given, as well as the kilowatt rate, so that the reader may make his own assumptions as to the total current generated, and find the total cost per KW.-hr. The only variable is "Supplies." Unless the load factor is so low as to permit of stopping one of the three units which have in calculations been assumed as always in service, the value of "Supplies" will not vary appreciably.

The cost of installation compares favorably with that of the best steam plants, and we may expect to better the figures given. We cannot, however, look for any great reduction, and as the cost of operation is, to the extent of 70%, made up of charges based on investment, we may say that the cost of $38.40 per KW.-year at the switchboard is susceptible of little, if any, improvement. By dropping the sinking fund rate to 2 % the cost would only be reduced to $35.00.

As stated in Table III., no allowance has been made for the value of the blast furnace gas. If the surplus were not thus utilized for the development of power it would be lost. If the same amount of heat which is supplied by the blast furnace gas were obtained from coal at $2.00 per net ton or natural gas at 7 cts. per 1,000 cu. ft., the cost of fuel for the gas engine per KW. per year would be approximately $12.50 in either case. For the steam engine the expense would only in rare instances be less than $25.

The value of the surplus gas may also be taken as the sum of the capital charge of 5% and the profits, amounting in Class "A" to $87,000, and in Class "B" to $90,000 per annum for a blast furnace plant of which the yearly output is 300,000 tons of iron. An increase in profits to the iron manufacturer of approximately 30 cts. per ton may thus be realized. If this is true of a plant which can convert but 25% of the surplus gas available, still better results may be expected from those at which the percentage of surplus convertible is greater. It would not be impossible to realize 75 cts. or more per ton, where 8 to 10 furnaces are grouped. No management can well afford to neglect a very thorough investigation of the conditions at its plant and its locality to determine whether they are favorable to the developments of power from surplus gas.

Wherever there is a large demand for power and cheap water-power is not available and blast furnaces are, the blast furnace gas engine power plant need fear no rival. We are not far from the day when the power house will be as much a part of every modern blast furnace plant as are the condenser and ammonia houses of the modern by-product coke plant.

TABLE II.—First Cost of Blast Furnace Gas Power Plant. Data.—Gas engines in both classes are 2,000 HP. each, 75 r. p. m. One unit in each case in reserve.

Items.	Class "A" 4 1,000 KW. units, 50% overload capacity.	Class "B" 4 1,500 KW. units, no overload capacity.
Land	$5,000	$5,000
Building	67,500	67,500
Engine foundations	6,000	6,000
Travelling crane	8,000	8,000
Piping	16,000	16,000
Compressors and engines	8,000	8,000
Pumps and engines	12,000	12,000
Exciters and engines	15,000	15,000
Switchboard, wiring, lamps	16,000	16,000
Generators	100,000	120,000
Gas engines	280,000	280,000
Exhaust stack	4,000	4,000
Gas washing plant	30,000	30,000
Gas holder and piping	10,000	10,000
Office and fixtures	2,500	2,500
Total cost	$580,000	$600,000
Cost per kilowatt total station capacity	145.00	100.00
Cost per kilowatt station capacity operated	193.33	133.33

MATHEMATICS OF THE PAPER LOCATION OF A RAILROAD.*

By J. C. L. Fish,† Assoc. M. Am. Soc. C. E.

The object of this article is to present the mathematical steps involved in preparing, from the paper location of a railroad, a set of mathematically consistent alinement notes by which to run the corresponding field location; and to suggest an orderly arrangement for the necessary computations.

Mr. W. B. Storey, Jr., in discussing a paper by Michael L. Lynch on Railroad Location, says:‡

On the Southern Pacific System the location is transferred from the paper to the ground, not by scaling, but by calculation. Each tangent is fixed, and the connecting curves are all calculated in the office by carrying the line from one fixed tangent around through the preliminary to the next tangent. These calculated notes are then given to a machine known as the locating party and put on the ground by it.

The writer does not remember having seen elsewhere any reference to the calculation of field notes; but in various articles on railroad location he has noted direct or implied reference to scaling.

To make clear what is meant by scaling and by calculating, and to show the advantage of calculating over scaling, let us find, by the two methods, the station and "plus" via the preliminary and via the location for the check point A, Fig. 1, the first crossing of the location and preliminary which have a common starting point, P_1.

BY SCALING.—The angle at P_1, between preliminary and location, is scaled in the course of preparing the notes for field location. Simply for the purpose of getting a check on the location at the point A we scale the distance P_1A on the location and the distance P_2A on the preliminary, thus obtaining the station and plus for A via each of the two lines. We now have of the triangle P_1P_2A the given side P_1P_2 (taken from the field notes of preliminary), the given angle P_1P_2A, the two scaled sides P_1A and P_2A, and one scaled angle, AP_1P_2. All the scaled quantities are affected by the errors of scaling, which are large compared with field errors, and it is evident that our values for the five parts of the triangle are mathematically inconsistent, since any three parts (which include one side) of a triangle determine the other parts. The result is that when the field party has located to A, and found they do not check on the preliminary within several feet, they have no means of telling how much of the error is due to surveying and how much to scaling. In this case the surveying checks the scaling, but there practically is no check on the field work.

BY CALCULATION.—By this method we scale only so many parts of the triangle P_1P_2A as will, together with the given part or parts, determine the size and shape of the triangle. Side P_1P_2 and angle P_1P_2A are known from the preliminary notes. If, then, we scale the angle P_2P_1A we shall have values for three parts of the triangle, from which we can compute the sides P_1A and P_2A. These five parts of the triangle—two given, one scaled and two computed—are mathematically consistent; and when the location party arrives at A and find they do not exactly check on the preliminary, they know that the error is all chargeable to field work (assuming that no errors have been made in computing). In this case the field work is really checked. Of course the error may be in running the preliminary or the location, or more probably in both. The check is on the surveying on both lines between P_1 and A. If the error is not within the limit of error permitted, the location is re-run (using the same notes), and if this is found to be practically correct, the next step is to re-run the preliminary from P_1 to A. If the error is not discovered here it must be found in the office work—computations or copying of notes. It cannot be due to scaling.

MATHEMATICS OF PAPER LOCATION: USING RECTANGULAR CO-ORDINATES.—The chief points of the preliminary, surveyed by any method or combination of methods, have been plotted by rectangular co-ordinates, and our map shows points P_1, P_2, P_3, P_4, P_5, P_6 and P_7. The co-ordinates of each point are written by the point, the value of the abscissa first. The engineer has

TABLE III.—COST OF POWER AT STATION SWITCHBOARD (BASED ON TABLE II.; VALUE OF BLAST FURNACE GAS NOT CONSIDERED).

	Class "A" 4 1,000-KW. units, 50% overload capacity. Load factor 50% 24-hour power.		Class "B" 4 1,500-KW. units, no overload capacity. Load factor 80% 24-hour power.	
	Per annum.	Per KW.-hr. generated. Cents.	Per annum.	Per KW.-hr. generated. Cents.
Superintendence and wages	$20,450	0.156	$20,450	0.065
Supplies, including water	18,800	0.143	18,800	0.0597
Repairs and maintenance	11,600	0.0885	12,000	0.0382
Taxes and insurance	8,700	0.0665	9,000	0.0286
Capital charges:				
5% on investment	29,000	0.578	30,000	0.248
8% sinking fund	46,800	.....	48,000	.....
Total operating cost	$135,350	1.0320	$138,250	0.4395
Cost per KW.-year of station capacity operated	45.12	.....	30.75	.....
Cost per KW.-year power generated	90.24	.....	38.40	.....
Assuming profit of 10% on investment	58,000	.....	60,000	.....
Total price	$193,350	1.475	$198,250	0.630
Price per KW.-year power generated	128.90	.....	55.07	.....

*Copyright, 1905, by M. C. Clark.
†Associate Professor of Civil Engineering, Leland Stanford, Jr., University, Palo Alto, Cal.
‡Trans. Am. Soc. C. E., Vol. XXXI., p. 92.

drawn in pencil on the map the location P_1, PC_1, PT_1, PC_2, PT_2, PC_3. PC_1 and PT_1 are respectively the beginning and end of a 6-degree curve; and PC_2 and PT_2 are the beginning and end respectively of an 8-degree curve. PC_3 is the beginning of a curve, and is considered the end of this location. It will be noticed that each curve is numbered, and that each letter standing for a curve element is given for a subscript the number of its curve; e. g., the central angle of curve No. 2 is $\triangle_2$. All dimensions which appear on the map at this time are put in parentheses on our figure in order to distinguish them from the quantities computed in the work of getting out the location notes, which are written without parentheses. We have nothing to do here with the question of the proper place for the location line on the map: that is an engineering problem, while our work is to take the location line as we find it, and get out the notes for transferring it to the ground. Having no need of the topography in what follows, it has been omitted from our map. The distances have been computed here to the nearest foot only, although it is customary to consider tenths of a foot. Of course, in any given location the limit of error in field work should control the precision of computation. To save space there have been omitted from Fig. 1 the station numbering of the preliminary and of the location.

1. PRODUCE THE TANGENTS to intersect at V_1 and V_2.

2. SCALE THE CO-ORDINATES of the initial point, the final point, and of all the points of tangent intersection. In our case, the initial point of the location is at the origin of co-ordinates, and coincides with the initial point of the preliminary. The co-ordinates of V_1 and V_2 and PC_3 are written by the points on the map as they are scaled off,—x first and y second.

No further scaling is done, except that every computed distance and angle should be roughly checked by scaling. We are now ready to take up the computing.

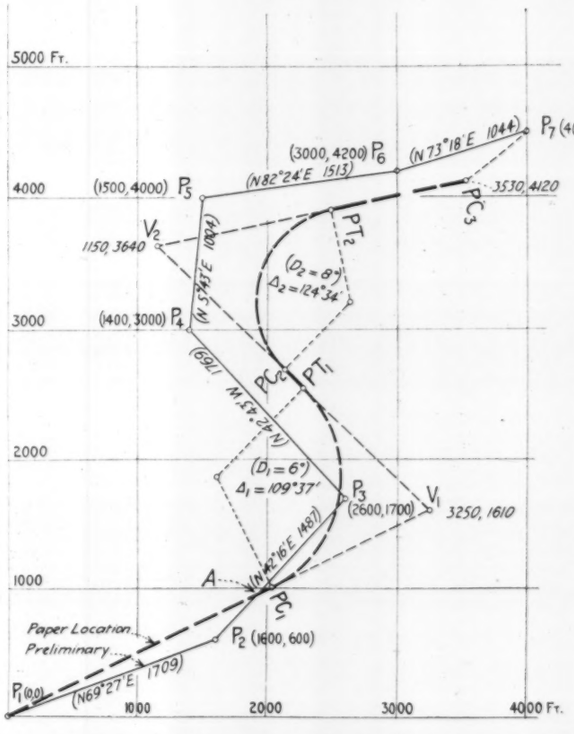


FIG. 1. METHOD OF PLOTTING PAPER LOCATION OF A RAILWAY LINE.

3. COMPUTE THE BEARINGS AND LENGTHS OF TANGENTS PRODUCED TO INTERSECTION.—The plus direction of the y-axis is taken as north. The tangent of the bearing of P_1V_1 is

$$\tan \beta_{P_1V_1} = \frac{x_{V_1} - x_{P_1}}{y_{V_1} - y_{P_1}} = \frac{3,250 - 0}{1,610 - 0}$$

(Throughout, the subscript of an x or a y of any point is the symbol which designates that point; and the subscript of β is composed of the two symbols which designate the terminal points of a line.)

$$P_1V_1 = \frac{x_{V_1} - x_{P_1}}{\sin \beta_{P_1V_1}}$$

$\log 3,250 = 3.51188$	$\log 3,250 = 3.51188$
$\log 1,610 = 3.20683$	$\log \sin 63° 39' = 9.95236$
$\log \tan 63° 39' = 0.30505$	$\log 3,627 = 3.55952$

From the logarithmic computation we find the bearing and length of P_1V_1 to be N 63° 39′ E, 3,627 ft.

The tangent of the bearing of V_1V_2 is

$$\tan \beta_{V_1V_2} = \frac{x_{V_2} - x_{V_1}}{y_{V_2} - y_{V_1}} = \frac{1,150 - 3,250}{3,640 - 3,250} = \frac{-2,100}{2,030}$$

and

$$V_1V_2 = \frac{x_{V_2} - x_{V_1}}{\sin \beta_{V_1V_2}}$$

$\log -2,100 = 3.32222$ n	$\log 2,100 = 3.32222$
$\log 2,030 = 3.30750$	$\log \sin 45° 58' = 9.85669$
$45° 58' = 0.01472$ n	$2,921 = 3.46553$

That is, the bearing and length of V_1V_2 are N 45° 58′ W, 2,921 ft. (The negative value of the tangent shows that the bearing is either S E or N W, but the map indicates that the bearing is N W.)

The tangent of the bearing of V_2PC_3 is

$$\tan \beta_{V_2PC_3} = \frac{x_{PC_3} - x_{V_2}}{y_{PC_3} - y_{V_2}} = \frac{3,530 - 1,150}{4,120 - 3,640} = \frac{2,380}{480}$$

and

$$V_2PC_3 = \frac{x_{PC_3} - x_{V_2}}{\sin \beta_{V_2PC_3}}$$

$\log 2,380 = 3.37658$	$\log 2,380 = 3.37658$
$\log 480 = 2.68124$	$\log \sin 78° 36' = 9.99135$
$\log \tan 78° 36' = 0.69534$	$\log 2,428 = 3.38523$

giving for V_2PC_3 the bearing and length of N 78° 36′ E, 2,428 ft.

We now scale the map for a rough check on these computed bearings and distances.

4. COMPUTE CENTRAL ANGLES OF CURVES.—It is evident from the map that the central angle for curve No. 1 is

$$\triangle_1 = \beta_{P_1V_1} + \beta_{V_1V_2} = 63° 39' + 45° 58' = 109° 37';$$

and the central angle for curve No. 2 is

$$\triangle_2 = \beta_{V_1V_2} + \beta_{V_2PC_3} = 45° 58' + 78° 36' = 124° 34'.$$

We roughly check these values by scaling the map with the protractor.

5. COMPUTE TANGENT-DISTANCES OF CURVES.—Using a "table of tangent-distances for a 1° curve" we find the tangent-distance for curve No. 1 is

$$T_1 = 1,355;$$

and for curve No. 2,

$$T_2 = 1,364.$$

We obtain a rough check on these by scaling.

If in any case the value of $\triangle$ is beyond the limits of the table, of course the tangent-distance must be computed from the formula:

$$T = R \tan \triangle 2.$$

6. COMPUTE CURVE LENGTHS.—Length of curve is equal to one hundred times the ratio of central angle to degree of curve.

Length of curve No. 1 is

$$L_1 = 100\ \triangle_1 / D_1 = 100\ (109° 37') / 6° = 100\ (109.62) / 6 = 1,827.$$

Length of curve No. 2 is

$$L_2 = 100\ \triangle_2 / D_2 = 100\ (124° 34') / 8° = 100\ (124.57) / 8 = 1,557.$$

We now step off the curve lengths on the map to obtain a rough check on the computed values.

7. COMPUTE LENGTHS OF CENTER-LINE TANGENTS.—The length of the first tangent, as the map shows, is

$$P_1PC_1 = P_1V_1 - T_1 = 3,627 - 1,355 = 2,272.$$

The second tangent is

$$PT_1\ PC_2 = V_1V_2 - (T_1 + T_2) = 2,921 - (1,355 + 1,364) = 202;$$

And the third tangent is

$$PT_2\ PC_3 = V_2\ PC_3 - T_2 = 2,428 - 1,364 = 1,064.$$

The rough check by scaling is now employed.

8. COMPUTE STATION AND PLUS FOR CURVE AND TANGENT POINTS.—The station and plus for P_1 is 0 + 00.

The station and plus for PC_1 is $P_1PC_1 = (22 + 72)$.

The station and plus for PT_1 is $(22 + 72) + L_1 = (22 + 72) + 1,827 = (40 + 99)$.

The station and plus for PC_2 is $(40 + 99) + PT_1\ PC_2 = (40 + 99) + 202 = (43 + 01)$.

The station and plus for PT_2 is $(43 + 01) + L_2 = (43 + 01) + 1,557 = (58 + 58)$.

The station and plus for PC_3 is $(58 + 58) + PT_2\ PC_3 = (58 + 58) + 1,064 = (69 + 22)$.

Now we prick off the stations on the map, thus checking roughly these values.

9. COMPUTE ELEMENTS FOR CHECK POINTS.—On our map the location crosses the preliminary at the point A, which we use as a check point. There is no corresponding point at the other end of the line, and, in order to obtain a check, we draw the line PC_3P_7 and compute its bearing and length, to be run in the field as an auxiliary line to check on point P_7.

CHECK POINT A.—We first write the equations for lines, P_2P_3 and P_1V_1. The general equation for a straight line is $y = ax + b$,

where $a = (y_n - y_k) / (x_n - x_k)$

and $b = y_k - ax_k$.

(The subscripts k and n refer to the initial and final points respectively of any line.)

For line P_2P_3 $a = (y_3 - y_2) / (x_3 - x_2) = (1,700 - 600) / (2,600 - 1,600) = 1,100 / 1,000 = 1.1$; and $b = y_3 - ax_3 = 600 - 1.1\ (1,600) = -1,160$. Equation of line P_2P_3 is, therefore,

$$y = 1.1\ x + (-1,160)$$

or

$$y = 1.1\ x - 1,160.$$

For line P_1V_1

$$a = \frac{y_{V_1} - y_{P_1}}{x_{V_1} - x_{P_1}} = \frac{1,610 - 0}{3,250 - 0} = 0.4954$$

and

$$b = y_{P_1} - ax_{P_1} = 0 - a\ (0) = 0$$

making the equation of P_1V_1

$$y = 0.4954\ x.$$

We now compute the co-ordinates of the point A of intersection of P_2P_3 and P_1V_1.

If the equation of the first line be written

$$y = ax + b$$

and the equation of the second be written

$$y = a'x + b'$$

then the co-ordinates of this common point are:

$$x = \frac{b' - b}{a - a'};\ y = ax + b$$

and a check is had in the equation

$$y = a'x + b'$$

Substituting numerical values of a, b, a′, b′, for our point A, we get:

$$x_A = \frac{0 - (-1,160)}{1.1 - 0.4954} = \frac{1,160}{0.6046} = 1,919$$

$$y_A = 1.1\ (1,919) + (-1,160) = 951$$

We scale the map to get a rough check on the computations.

It remains to find for A the station and plus via each line.

The distance

$$P_2A = \frac{x_A - x_2}{\sin \beta_{23}} = \frac{1,919 - 1,600}{\sin 42°16'} = \frac{319}{\sin 42°16'}$$

$$\log \quad 319 = 2.50379$$
$$\log \sin 42° 16' = 9.82775$$
$$\log \quad 474.3 = 2.67604$$

The logarithmic computation makes $P_2A = 474.3$.
The station and plus of A on the preliminary is
$P_1P_2 + P_2A = 1,709 + 474.3 = 21 + 83.3$.
The distance

$$P_1A = \frac{x_A - x_{P_1}}{\sin \beta_{P_1V_1}} = \frac{1,919 - 0}{\sin 63°39'} = 2,141$$

as computed by logarithms here:

$$\log \quad 1,919 = 3.28299$$
$$\log \sin 63° 39' = 9.95236$$
$$\log \quad 2,141 = 3.33063$$

The station and plus for A on the location is, then, 21 + 41.

Scale the map to roughly check these values.

It is evident that station 21 + 41 on the location survey should coincide with station 21 + 83.3 on the preliminary.

In cases in practice a check point may be conveniently obtained by producing a location tangent to intersect the preliminary, and making the computation in the foregoing manner.

CHECK LINE PC_3P_7.—When a crossing of the location with the preliminary is not near at hand for a desired check on the field work, a check line, or tie line, is drawn between a chosen point of the location and a chosen point of the preliminary; and the bearing and length of the check line are computed. As an example, draw the check line PC_3P_7, and find the bearing by the equation:

$$\tan \beta_{PC_3P_7} = \frac{x_{P_7} - x_{PC_3}}{y_{P_7} - y_{PC_3}} = \frac{4000 - 3,530}{4,500 - 4,120} = \frac{470}{380}$$

and find the length

$$PC_3P_7 = \frac{x_{P_7} - x_{PC_3}}{\sin \beta_{PC_3P_7}}$$

log 470 = 2.67210	log 470 = 2.67210
log 380 = 2.57978	log sin 51° 03′ = 9.89081
log tan 51° 03′ = 0.09232	log 604.4 = 2.78129

We find the bearing and length of PC_3P_7 to be N 51° 03′ E. 604.4 ft. The location having been carried in the field to the point PC_3, the transitman deflects to the left at this point the angle $\beta_{V_2PC_3} - \beta_{PC_3P_7} = 78° 36' - 51° 03' = 27° 33'$, and the chainmen lay off 604.4 on this course, and should by so doing arrive precisely at P_7 on the preliminary.

10. COMPUTE CURVE DEFLECTIONS.—PC_1 is 22 + 72 making the first sub-chord on the 6-degree curve, 28 ft. The corresponding deflection is .28 x 3° = .28 x 180′ = 50′, i. e., the tangent deflection for station 23 is 50 minutes. The deflection for sub-chord at PC_2 is .99 x 240′ = 238′ = 3° 58′. The deflection for sub-chord at PT_1 is .99 x 180′ = 178′ = 2° 58′. The deflection for sub-chord at PT_2 is .58 x 240′ = 139′ = 2° 19′.

ALGORITHMS.—To facilitate explanation the foregoing computations have been put down in a rambling manner which makes the computed quantities hard to find when wanted. For a longer location than this, economy of time and effort requires that the routine computations be systematically arranged, that like operations as well as like quantities may be brought together. By this means entering the data and making the computations in a short time become largely mechanical processes, and at the end the computed quantities stand in tabular order and may be quickly found when wanted. For the computations of this article the following computation forms, or algorithms, are suggested. While these may not present the best arrangement, they will at least show the advantage of order over disorder. The reader may be interested in the fact that the writer's students buy for their computing, letter-size sheets of paper ruled on one side with the special design shown in Fig. 2. By the use of this paper any algorithm may be followed without drawing lines, and columns of digits are kept vertical automatically.

Algorithm 1 is for computing the bearing and length of lines which are terminated by points of known co-ordinates. Column A contains the numbers of the horizontal lines of the algorithm. Column B contains the symbols. x_k, y_k designate the co-ordinates of the initial point of any line; x_n, y_n designate the co-ordinates of the final point of the line; β_{kn} is the bearing, and d_{kn} is the length of

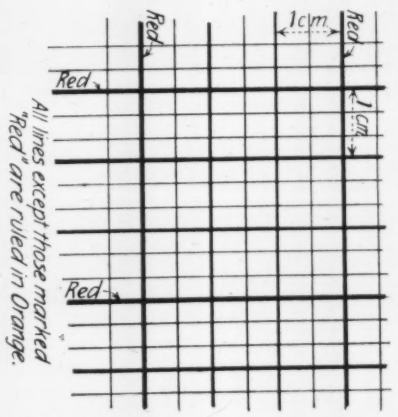


Fig. 2. Design for Rulings on Computing Paper.

the line. The lower half of this algorithm has to do with the check equation:

$$\text{hypot.} = (\text{base}^2 + \text{altitude}^2)^{1/2}.$$

Notice that the values on line 21 check those on line 12. Of course this check will not detect errors made in entering values of co-ordinates on lines 1, 2, 3, 4.

When a table of squares is at hand it may well be used in place of logarithms for the computation of checks. Columns C, D, E, F give for the line P_1V_1, V_1V_2, V_2PC_3, and PC_3P_7 respectively, the numerical quantities corresponding to the symbols of Column B. It is suggested that the order of steps in computing be: (1) Enter the co-ordinates for all the lines concerned; (2) Set down on lines 5 and 6 the differences; (3) Enter all the logs on line 7; (4) Enter all the logs on line 8, and so on; every operation in Column C being immediately repeated for the succeeding columns.

Algorithm 2: Column A contains the numbers which have been used to designate the curves. In B will be found the degree of each curve. Each degree of curve is repeated in parenthesis, with the minutes expressed in decimal of a degree. In C are entered the central angles, each of which has been computed from two values of β taken from Algorithm 1. For example: C2 (i. e., the quantity in Column C and on line (2) is 109° 37′, which is the sum of C13 (Alg. 1) and D13 (Alg. 1). C3 and C6 give the central angle with minutes reduced to decimal of a degree. D contains the tangent distance for each curve. E contains the curve lengths. In F are entered the lengths of tangents produced to intersection points, copied from line 12 of Alg. 1. G contains the amounts to be subtracted from quantities in F to obtain the quantities in H. For example: G4 is the sum of D2 and D5, and H4 is F4 less G4. I contains the station and plus for each point of curve; and J contains the station and plus for each point of tangent. I2 is rewritten from H1; J2 is 12 plus E2; I5 is J2 plus H4; J5 is I5 plus E5, and so on. K and L contain the subchord deflections.

Algorithms 3 and 4 will need no explanation.

11.—ALINEMENT NOTES FOR LOCATION.—We are now ready to enter the results of our computations in the field book in the usual form of alinement notes.

Location Alinement Notes.

Sta.	Curve	Point.	Deflections.	Computed Bearings.
69 + 22		PC_3	Check: Deflect 27° 33′ (bearing N 51° 03′ E) to left and run 604.4 to P_7 which is Sta. 84 + 26 on preliminary.	
....				
....				
60				
59				N 78° 36′ E
58 + 58		PT_2	62° 17′	N 16° 20′ E
58			59° 58′	
57			55° 58′	
....			.....	
45			7° 58′	
44			3° 58′	
43 + 01		PC_2 8° R	0° 00′	N 45° 58′ W
43				
42				
41				N 45° 58′ W
40 + 99		PT_1	54° 48.5′	N 8° 51′ E
40			51° 50′	
39			48° 50′	
....			.....	
25			6° 50′	
24			3° 50′	
23			50′	
22 + 72		PC_1 6° L	0° 00′	N 63° 39 E
22				
21 + 41			Check: This point is 21 + 83.3 on preliminary.	
21				
....				
2				
1				
0			This is Sta. 0 of preliminary. For first location course deflect 5° 48′ to left of first preliminary course.	

THE MATHEMATICS OF PAPER LOCATION: USING POLAR CO-ORDINATES.—To compute the location field notes without employing rectangular co-ordinates, proceed thus:

1. The location having been laid down on the map as shown, scale P_1V_1, V_1V_2, V_2PC_3, and with the protractor scale the bearings of these three lines.
2. Compute the central angles $\triangle_1$ and $\triangle_2$.
3. Compute curve lengths L_1 and L_2.
4. Compute tangent distances T_1 and T_2.
5. Compute lengths of tangents P_1PC_1, PT_1 PC_2 and PT_2PC_2.

ALGORITHM I.—Bearings and Distances on Location.

			Line P_1V_1	Line V_1V_2	Line V_2PC_3	Check Line PC_3P_7
1		x_k	0	3250	1150	3530
2		y_k	0	1610	4000	4120
3		x_n	3250	1150	3530	4000
4		y_n	1610	3640	4120	4500
5		$x_n - x_k$	3250	− 2100	2380	470
6		$y_n - y_k$	1610	2030	480	380
7	log	$(x_n - x_k)$	3.51188	3.32222 n	3.37658	2.67210
8	log	$(y_n - y_k)$	3.20683	3.30750	2.68124	2.57978
9	log tan	β_{kn}	0.30505	0.01472 n	0.69534	0.09232
10	log sin	β_{kn}	9.95236	9.85669	9.99135	9.89081
11	log	d_{kn}	3.55952	3.46553	3.38523	2.78129
12		d_{kn}	3627	2921	2428	604.4
13		β_{kn}	63° 39′	− 45° 58′	78° 36′	51° 03′
14	log	$(x_n - x_k)^2$	7.02376	6.64444	6.75316	5.34420
15	log	$(y_n - y_k)^2$	6.41366	6.61500	5.36248	5.15956
16		$(x_n - x_k)^2$	10560000	4410000	5664500	220900
17		$(y_n - y_k)^2$	2592000	4121000	230400	144400
18		$(x_n - x_k)^2 + (y_n - y_k)^2$	13152000	8531000	5894900	365300
19	log	" "	7.11900	693100	6.77048	5.56265
20	½ log	" "	3.55950	3.46550	3.38524	2.78132
21		$[(x_n - x_k)^2 + (y_n - y_k)^2]^{1/2}$	3627	2921	2428	604.4
A		B	C	D	E	F

ALGORITHM II.—Curves and Tangents on Location.

	Curve No.	Degree of curve.	Central angle.	Tangent distance.	Length of curve.	Length of tangent produced to intersection.	1 tang. dist. or sum of 2 tangdists.	Length of tangent between curves.	Sta. and plus for PC.	Sta. and plus for PT.	Subchord deflection for PC.	Subchord deflection for PT.
		D°	△	T	L	d			PC	PT		
1	....	.....	.....	....	....	3627	1355	2272	.....	.....	.....	.....
2	1	6°00′	109°37′	1355	1827	....	....	....	22 + 72	40 + 99	0°50′	2°58′
3	....	(6.00)	(109°.62)	....	....	....	....	....	.....	.....	.....	.....
4	....	.....	.....	....	....	2921	2719	202	.....	.....	.....	.....
5	2	8°00′	124°34′	1364	1557	....	....	....	43 + 01	58 + 58	3°58′	2°19′
6	....	(8.00)	(124°.57)	....	....	....	....	....	.....	.....	.....	.....
7	....	.....	.....	....	....	2428	1364	1064	.....	.....	.....	.....
8	3	.....	.....	....	....	....	....	....	69 + 22	.....	.....	.....
	A	B	C	D	E	F	G	H	I	J	K	L

6. Write station and plus for P_1, PC_1, PT_1, PC_2, PT_2, and PC_3.

7. Find preliminary station and plus, and location station and plus, for check point A, thus: (a) Compute angles of triangle P_1P_2A; (b) From the known side and angles of this triangle compute the sides P_1A and P_2A; (c) The preliminary station and plus for A is $P_1P_2 + P_2A$; and the location station and plus for A is P_1A.

8. Having drawn on the map the check line PC_2P_2, compute the length and bearing of this line. This is done by treating PC_2P_2 as the "missing side" of the closed figure $AP_2P_4P_5P_7PC_3V_2V_1A$.

9. Write the alinement notes in the field book.

The work of finding the "missing side" in Step 8, just above, involves practically all the operations required to compute the co-ordinates of the chief points of our map from the field notes of the preliminary survey.

Computing from the field notes the rectangular co-ordinates of the chief points of a survey is analogous to computing from the level notes the elevations of the stations on a profile, and has similar advantages.

LINE IMPROVEMENTS BETWEEN INDIANAPOLIS AND CINCINNATI, C., C., C. & ST. L. R. R.

By Geo. A. Stearns.*

The Cleveland, Cincinnati, Chicago & St. Louis R. R., better known as the Big Four, has recently completed a great improvement in its line from Indianapolis to Cincinnati. Increased traffic called for double tracking, and the company at the same time took the opportunity to straighten and regrade a long section. This work has been in progress for the past two years, and has cost between $2,000,000 and $3,000,000.

The portion of the system under consideration was originally a granger line, and was built as cheaply as possible. The drop from the central plateau of Indiana to the Ohio valley is over 500 ft. in about 17 miles. The road follows for a considerable distance the valley of Tanner's Creek, an unimportant tributary of the Ohio, and the old line crossed the creek 14 times on steel bridges. Some of the curves ran as high as 6°, and the grade was so heavy that a pusher engine was in use constantly for the 14 miles from Guilford to Sunman, Ind.

The improvement work included reducing the grades, straightening the line, replacing the bridges, and double tracking, and this work had to be done without interfering with the regular traffic. The heaviest curve is now but 2½°, and the maximum grade is 1.05%, and the pusher grade has been reduced 3½ miles. The new line intersects the creek 19 times, but by changing the course of the stream the number of crossings has been reduced to 13, with a consequent saving in bridge construction. All the bridges are now of concrete, instead of steel as before.

In planning the bridges consideration had to be taken of the character of the stream. Tanner's Creek drains a wide area, and has a fall of something like 100 ft. to the mile, and is subject to sudden risings at short notice. A very large body of water must thus be taken care of, so the bridges had to be of more spans than the insignificant character of the stream at ordinary water seems to demand. Moreover, the Ohio at high water backs as far as Guilford, and thus another factor enters into consideration.

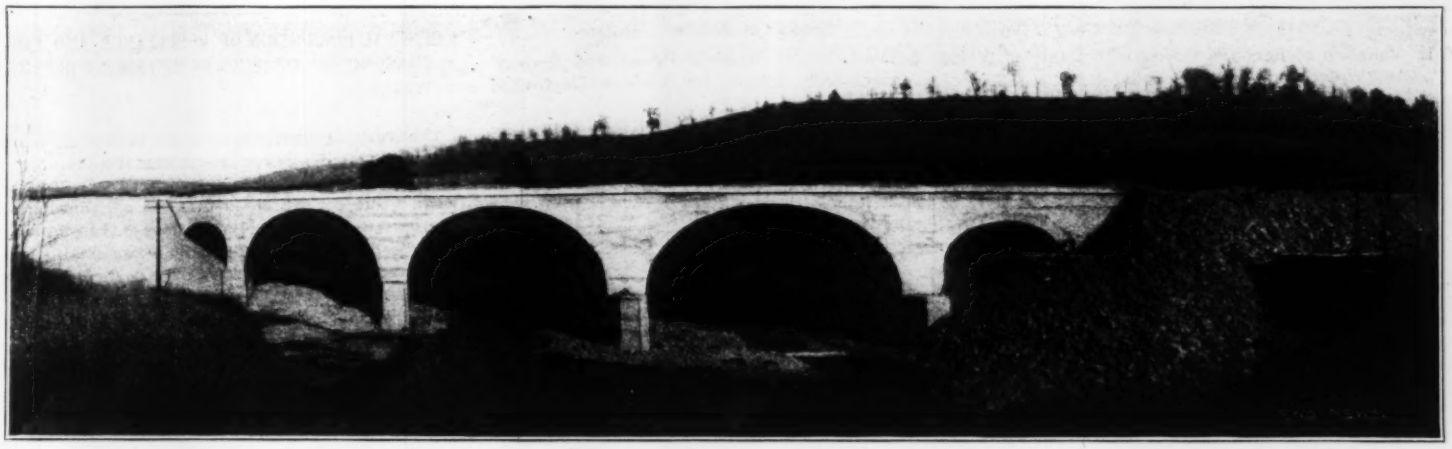
Some of the cuts were of a very heavy character. One at Guilford called for excavation to the depth of 125 ft. and another at Weisburg to 93 ft. A single mile of track between Manchester and Weisburg cost $370,000, there being three cuts, and three bridges. For construction the work was divided into six sections, each under the supervision of an engineer of the road. The new line crosses the old 16 times, and during construction each of these had to be provided with temporary track. At one time 16 steam shovels were at work. As fast as a section was completed it was put into service, and the entire line was in working order by the middle of December, though it required considerable longer to put on the finishing touches.

The original contract for grading was made with L. M. Webb, of Cincinnati, but after two months' work Mr. Webb surrendered the contract, and it was taken over by the Schutt Improvement Co. of St. Louis, who carried it to completion. The contracts for the bridges were taken by The Moore-Mansfield Construction Co. of Indianapolis, and I. D. Tuttle, and Williams Bros. & Morse of Cleveland. The Moore-Mansfield Co. built 19 concrete structures, large and small.

The bridge illustrated is characteristic. This is No. 168, one mile west of Guilford, Ind. It crosses the creek at an angle of 45°. Of its five spans three are 60 ft., and two 30 ft. It will be noticed how the gravel filling has been allowed to flow down into and around the end spans, thus obviating the necessity of wings. It was necessary to go down 19 ft. below water level to find suitable foundations, and the bridge rises 40 ft. above. It is 322 ft. long, and 33 wide. The concrete was mixed in the proportions: 1 cement to 8 gravel for the foundations, 1, 2½ and 5 for the foundations, and 1, 2 and 1½, and 4 for the arches. It required 5,650 cu. yds. of concrete.

Bridge No. 172, at Guilford, another of the Moore-Mansfield structures, is on a 80° skew, and has three spans of 60 ft. each. It is 228 ft. long, 35 ft. wide, and 58 ft. high, requiring 6,345 cu. yds. of concrete. Bridge No. 200 is one mile east of Manchester. It is of three spans with wings, at an angle of 60°. It is 229 ft. long, 35 ft. wide, and 58 ft. high, and called for 6,345 cu. yds. of concrete. The entire amount of concrete used in the construction of the bridges was 63,418 cu. yds.

The division is now working on double track for the distance improved, and is equipped with Taylor block signals with four stations. Each block station is equipped with an east and west siding of 2,500 ft. The company expects to reduce the running time from Cincinnati to Indianapolis 30 minutes by the changes, and to materially increase its tonnage.



TYPICAL EXAMPLE OF CONCRETE BRIDGE WORK ON CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS R. R. IMPROVEMENT.

*25 West 26th St., Indianapolis, Ind.

ALGORITHM III.—Line Equations.

Formulas: $a = (y_n - y_k) / (x_n - x_k)$; $b = y_k - ax_k$.

		Line P_2P_3	Line P_1V_1
1	x_k	1600	0
2	y_k	600	0
3	x_n	2600	3250
4	y_n	1700	1610
5	$y_n - y_k$	1100	1610
6	$x_n - x_k$	1000	3250
7	$\log (y_n - y_k)$	3.04139	3.20683
8	$\log (x_n - x_k)$	3.00000	3.51188
9	$\log a$	0.04139	9.69495
10	a	1.1	0.4954
11	$\log x_k$	3.20412	.....
12	$\log ax_k$	3.24551	.....
13	ax_k	1760	0
14	b	− 1160	0
15	(Eq.) $y = ax + b$	$y = 1.1x - 1160$	$y = 0.4954x + 0$
		A	B	C

ALGORITHM IV.—Co-ordinates of Intersection Point.

Formulas: $x = (b' - b) / (a - a')$; $y = ax + b$; check, $y = a'x + b'$.

		Check Point A.
1	(Eq.) $y = ax + b$	$y = 1.1x - 1160$
2	(Eq.)' $y = a'x + b'$	$y = 0.4954 + 0$
3	a	1.1
4	a'	0.4954
5	b	− 1160
6	b'	0
7	$b' - b$	1160
8	$a - a'$	0.6046
9	$\log (b' - b)$	3.06446
10	$\log (a - a')$	9.78147
11	$\log x$	3.28299
12	$\log a$	0.04139
13	$\log a'$	9.69495
14	$\log ax$	3.32438
15	$\log a'x$	2.97794
16	ax	2110.
17	$a'x$	950.5
18	x	1919.
19	$y (= ax + b)$	950.
20	$y (= a'x + b')$	950.5

THE RELATION OF DEPTH OF WATER TO SPEED AND POWER OF SHIPS.

Some interesting data recently presented in Engineering News on the subject of change of draft and trim of vessels in motion,* showed very clearly that the behavior of a moving ship depends on the depth of water under the keel. Those data suggested also that the power-consumption of a vessel at given speed is affected by depth of water. Such a relation is of wider interest than the changes in draft or trim, but hitherto little has been available in the way of definite knowledge about the power relation. An experimental investigation of the subject made a year ago in the German Navy should therefore be interesting, the more so as the experiments were made with a full-size vessel (as against model tests), and at such speeds that the reaction of the bottom upon the ship's resistance was felt through a very great depth of water. The investigation is reported in the "Zeitschrift des Vereines Deutscher Ingenieure" of Dec. 10, 1904, by Naval Constructor Paulus, and the following summary is taken from that report.

Two trial trips of a certain torpedo-vessel of the German Navy, made on two different measured-mile courses, but otherwise under practically identical conditions, gave speeds differing by about 1½ knots. The slower speed was obtained over the shallower course, having a depth of water of 60 to 80 ft., while the other course was in water nearly 200 ft. deep. At first, going on the supposition that a depth of ten times the draft was

*See an article, "The Draft of Vessels in Motion in Shallow Channels Compared with Their Stationary Draft," by H. W. Babcock, Engineering News of Aug. 4, 1904, and a letter on the same subject by D. W. Taylor, Engineering News of Sept. 22, 1904.

sufficient to eliminate the influence of the bottom, the authorities were unable to understand this result. However, after a careful re-survey of the two courses it was decided that no other source of difference existed, and experiments were ordered to investigate the question of influence of depth of water on speed.

The deeper of the two trial courses in question was found to be ideally located for the purpose of the experiments. A flat bottom of very gradual slope enabled all depths from 23 ft. to 197 ft. to be had in a series of parallel courses, with practical absence of currents. Six courses were laid out, in depths of water respectively 7, 10, 15, 25, 40 and 60 m. (23, 33, 49, 82, 131 and 197 ft.). The torpedo-vessel S119 was used for the experiments. The dimensions of this vessel are not stated; Brassey gives them as: Length, 207.7 ft.; breadth, 22 ft.; draft, 8.9 ft.; displacement, 350 tons.

Six speeds were run, on consecutive days, over the group of six courses. The program for each day was as follows: Beginning with the deepest (197-ft.) course, the vessel ran over this course, then turned and steamed back over the 131-ft. course, then turned again and went over the 82-ft. course, and so on until the 23-ft. course had been run. Then it returned over the 23-ft. course and worked back in similar manner to the point of beginning. This entire double run was made at approximately the same speed, the steam valve being left untouched through the run except where necessary to maintain the speed reasonably uniform.

In a complete run as described, it will be seen that each course was covered twice, in opposite directions; the two results for each course were averaged to eliminate current and wind effects. The change in draft, from the beginning of the double run until the vessel returned to the same point, was only about 1¼ ins., which was almost negligible. Allowance for all differences in draft was made on the assumption that, for equal revolutions, speeds are inversely proportional to displacement, and hourly coal-consumption directly proportional to displacement.

The measurements made during the runs were the following: Total revolution of engines; Indicated power of all (6) cylinders; Mean speed of vessel; Trim of vessel, or longitudinal tilt compared with position at rest; Shape of water surface along the side of the vessel. The trim was measured by two intercommunicating water-gages separated one-tenth the vessel's length. The shape of water surface was measured from the deck by graduated rods at intervals of one-tenth the vessel's length.

The results are graphically summarized in the four diagrams, Figs. 1 to 4, herewith: They show (1) the variation of power with depth of water, for a number of different speeds; (2) the variation of power with speed, for six different depths, and in conjunction therewith the change in trim with increasing speed; (3) the variation in speed of revolution with speed of ship; and (4) the variation of slip of propeller with speed of ship. In all diagrams the speed-range is the range between 12 to 27 knots, while the total available depth-range, 7 m. to 60 m., is well covered by the six curves obtained. The indicated power is seen to vary from 300 H.P. to nearly 6,000 HP.

The actual speeds used in the six runs were about 12, 15, 18, 21, 24 and 27 knots respectively. Many of the curves of Fig. 1 are therefore interpolated. In this diagram it will be noticed that curves of three kinds occur. At low speed, as 12 knots, the power is uninfluenced by depth of water (beyond 23 ft.). At medium speed the power is very high in shallow water, decreasing rapidly up to 35 or 50 ft. depth and then remaining fairly constant with increasing depth of water. At very high speed, however, the required power rises as the depth of water is increased from 23 ft., reaching a maximum and then very gradually decreasing as the depth of water is further increased. The surprising result appears that at high speed the vessel consumed more power in water 200 ft. deep than for the same speed in water only 23 ft. deep, though at moderate speeds the shallow water consumes several times as much power as deep water.

In the horse-power-speed diagram, Fig. 2, there are curves of two kinds, for deep and for shallow water respectively, of which the former is the type. This deep-water curve rises from a value of about 300 H.P. for a speed of 12 knots, in roughly parabolic form to a value of about 5,600 H.P. for 27 knots. For any depth down to about 80 ft. (25 m.) the curve is identical in form with this one, and lies only slightly above it. The 15-m. curve, however, shows a radical departure from this type. It begins at practically the same value, for low speed, but at about 16 knots it rises suddenly and forms a pronounced hump, whose crest is in the neighborhood of 22 knots. Thence it rises much more gradually, and ultimately it crosses the deep-water curve, so that at very high speeds it calls for less power than the deep-water curve. The curves for depths of 10 m. and 7 m. show the same characteristics, but much more strongly and at lower speeds in the shallower water. Thus, the 7-m. curve leaves the deep-water curve at a speed as low as 13 knots, reaches a crest at about 16½ knots, and again crosses the deep-water curve at 23 knots, showing lower values than any other curve for speeds beyond 23 knots. The enormous jump in required power as the speed is increased from 13 to 14 knots (500 HP. to 2,800 HP.) is especially striking.

The curves of trim in Fig. 2 correspond generally with the power curves. In deep water the stern sinks gradually and progressively, while in shallow water the stern sinks very suddenly at a point corresponding to the jump in the power curve. Similar characteristics appear in Figs. 3 and 4, showing engine-speed and slip of propeller. However, these curves merely supplement, on the theoretical side, the power curves of Figs. 1 and 2.

It should be remarked that the tests here recorded covered six consecutive days, and were made in quiet water and under unusually favorable conditions. The results are, therefore, free from the influence of surface disturbance, as nearly as such tests can be.

The general effect of these experiments is to show that the influence of the bottom upon ship motion extends through a far greater depth of water than had hitherto been supposed. Further, in such depths as allow of influence of bottom, say, less than 60 ft., there is a certain range of speed which is extremely wasteful of power, better results being obtained with lower and with higher speeds. Experiments upon vessels of other types and larger sizes than the one here used will be necessary to establish the results on a more general basis and to exhibit their dependence on size and shape of vessel. The close relation between required power and trim of vessel, apparent from Fig. 2, suggests clearly that the causes operating to produce change of trim are the same as those which increase the resistance of the vessel.

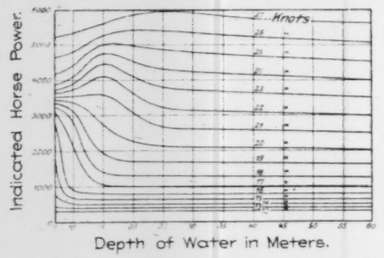


Fig. 1. Variation of Required Power with Depth of Water, for Various Speeds.

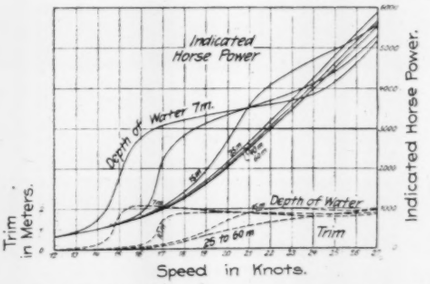


Fig. 2. Variation of Required Power and Trim of Vessel with Speed, for Various Depths of Water.

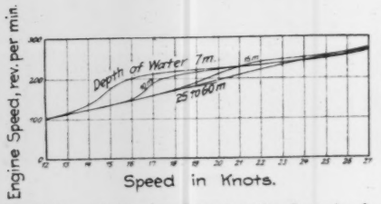


Fig. 3. Variation of Engine-Speed with Speed of Vessel, for Various Depths of Water.

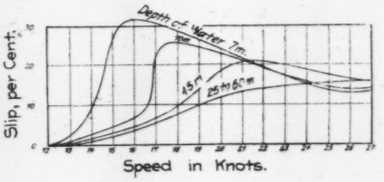


Fig. 4. Variation of Propeller Slip with Speed of Vessel, for Various Depths of Water.

RESULTS OF EXPERIMENTS MADE BY THE GERMAN NAVY ON TORPEDO VESSEL S 119.

A GENERAL DISCUSSION OF RESISTANCE AND POWER CONSUMPTION OF SHIPS IN DIFFERENT DEPTHS OF WATER.*

By D. W. Taylor.†

The very interesting recent trials of a German torpedo-boat destroyer in various depths of water (reported in the article just preceding.—Ed.) deal with a subject which is in need of thorough investigation, particularly in these days of increasing speed of vessels. There is a reasonable qualitative explanation, as it were, of the phenomena observed, but there is no theory at present which would enable us to estimate results with quantitative accuracy in advance of actual trials, and it does not appear likely that any such theory could be developed. As regards this problem, however, as with so many other problems concerning the resistance of vessels, it appears that we may confidently rely upon model experiments.

Some of the changes from deep water conditions in the fluid motions around a vessel under way in shallow water are obvious upon consideration. When the volume of water around the moving vessel is restricted, there necessarily follows intensified motion of the restricted volume. As a vessel advances into still water, whether shallow or deep, we find that in the vicinity of the bow the water moves forward, outward and downward to make way for it. At a comparatively short distance abaft the bow, however, the forward motion ceases. The water still moves outward and downward to make way for the body of the vessel, but also moves aft. This sternward motion of the water continues until within a comparatively short distance of the stern, where the water closing in and up behind the vessel has a forward velocity as well. Thus the actual relative velocity of the water past the surface of the vessel varies from point to point, and in practice will be, on the average, greater than the velocity of the vessel with reference to undisturbed water. When the vessel is in shallow water the increased velocities of the water for the same speed of the vessel must cause somewhat greater frictional resistance. This increase of frictional resistance must, however, be very small, except when a vessel is nearly dragging the bottom.

When we come to consider the method by which

*An article suggested by the account of the German torpedo vessel experiments given in the article just preceding, proofs of the article having been sent to Mr. Taylor with a request for discussion upon them.—Ed.

†Naval Constructor, U. S. N., Washington Navy Yard, Washington, D. C.

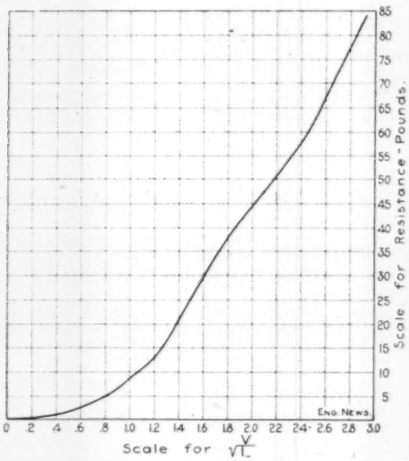


Fig. 1. Curve of Resistance of 20-Ft. Ship-Model.

Curve plotted on V ÷ √L as base.
V = Speed in knots.
L = Length of model on water-line, in feet.
Displacement of model = 773 lbs.

the water is forced aft, we approach the true cause of the greater resistance in shallow water. The pressure around the bow of the advancing vessel is greater than in undisturbed water. It is this excess pressure which pumps the water aft, as it were, but, owing to the fact that the water surface is free, this excess pressure also raises the water in its vicinity, producing a wave which travels away from the ship and carries energy with it. In shallow water this excess pressure and the resulting waves are greater than in deep water.

It is well known that shallow water waves differ from deep water waves. The trochoidal theory of waves, although not exact, appears to agree fairly well with all observed phenomena. The treatise entitled "Wave Action in Relation to Engineering Structures," by Captain D. D. Gaillard, Corps of Engineers, U. S. Army, recently published as No. 31, Professional Papers, Corps of Engineers,* contains a very complete abstract of the work of previous investigators of water waves and a mass of original observations and comparisons between observed results and theoretical formulae. Captain Gaillard found that observed results were sufficiently close to the results of the trochoidal theory to confirm the substantial accuracy for practical purposes of the latter. Under the trochoidal theory, when an indefinite series of similar and equal parallel waves advances through deep water, each particle of water describes a circular orbit, and the speed of advance of the waves is dependent only upon their length, being given by $v = \sqrt{5.123\,l} = 2.265\sqrt{l}$, where v is the speed of advance of the wave in feet per second, and l is the length in feet from crest to crest. If the speed of advance in knots is denoted by V, we have $V = 1.341\sqrt{l}$. In shallow water, for a series of waves as above, the circular orbits become ellipses with major axes horizontal, and the speed of advance for a given value of l is less. The table below gives relative velocities, the speed of advance in water of a given depth depending only upon the length of the wave.

TABLE I.—Comparison Between Velocities of Waves in Shallow and Deep Water.

Depth Ratio.*	Velocity Ratio.†	Depth Ratio.	Velocity Ratio.
.01	.251	.25	.958
.02	.352	.30	.977
.03	.431	.35	.987
.04	.496	.40	.993
.05	.552	.45	.996
.075	.663	.50	.998
.10	.746	.60	.999
.15	.858	.75	.9999
.20	.920	1.00	.999999

*Depth of water as a fraction of the wave length.
†Velocity of wave in shallow water as a fraction of velocity of deep water wave of same length.

The trochoidal wave theory must be applied with caution to ships, but it has been thoroughly established by experiments that the length from crest to crest of the wave caused by a vessel at a given speed is reasonably close to the length of the trochoidal wave corresponding to that speed. The wave-making length, as it is called, of the vessel is a somewhat variable length, and greater than the length of the vessel itself, that is to say, the distance between the crests of the natural wave set up at the bow and the natural wave set up at the stern is somewhat greater than the length of the vessel. Taking actual ships, for very fine vessels the wave-making length is but little, say, 5% or so, greater than the water-line length, while for bluff ships it may be 20% greater in extreme cases. The wave-making length of a ship appears to increase with the speed.

The bow and stern tend each to set up a distinct system of waves, which fall behind the vessel and spread sideways, carrying off the energy which is supplied to each system from the resistance of the vessel.

The interactions of the bow and stern wave systems have a powerful influence upon the resistance. It is obvious that if the second crest of the bow wave placed itself in the hollow of the stern wave, the total final resultant wave disturbance would be very much reduced, while, on the contrary, if the crest of the bow wave were to reinforce the natural crest of the stern wave, it would thereby aggravate wave action and consequently aggravate resistance. In practice, in actual ships, the action of the bow wave system upon the stern wave system first becomes of importance, except for very bluff vessels, at a speed in knots about equal to .85 √L, where L is the length of the vessel in feet, and there is a maximum reinforcement of the stern wave by the bow wave at about a speed equal to √L. At this speed there is a bow wave crest forward, the second crest of the bow wave system appears against the side of the ship a little aft of amidships, and the third crest is astern of the ship just in a position to reinforce the first natural crest of the bow wave system. Starting from this point, if we increase the speed beyond √L we reach a more favorable condition, the second crest of the bow wave system moves aft along the quarter of the ship, supporting the stern, as it were, and the third crest, moving aft from its former position, fills up the first hollow of the stern wave system and reduces the total wave disturbance. Hence, corresponding to the speed √L, we have a marked "hump" upon the curve of resistance, and corresponding about to V = 1.2 √L we have a distinct hollow. Suppose, now, we increase the speed again. The second bow wave crest continues to move aft and reinforces the first stern wave crest. The maximum effect occurs somewhere near a speed of 1.5 √L to 1.6 √L.

This results, then, in another distinct hump in the curve of resistance. Evidently, however, since this is the second crest of the bow wave there can be no more humps on this theory short of infi-

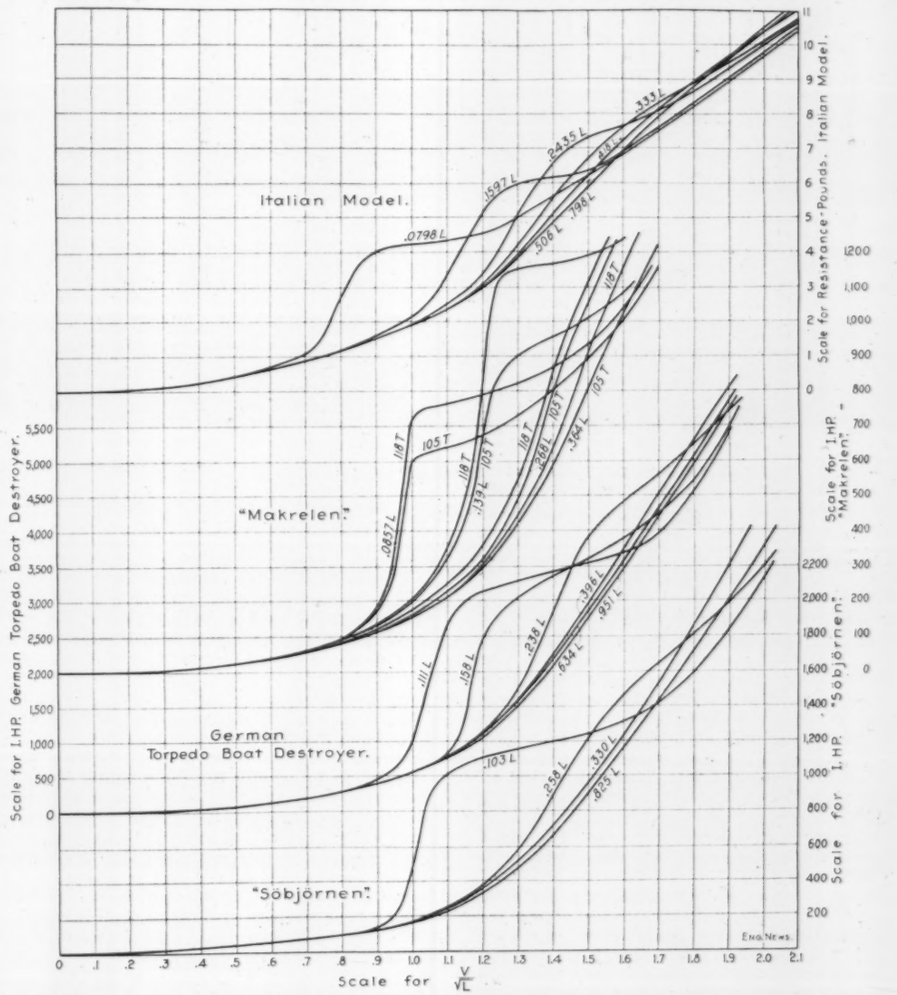


FIG. 2. CURVES OF RESISTANCE AND I. HP. OF HIGH-SPEED BOATS, FOR DIFFERENT DEPTHS OF WATER.

Curves plotted on V ÷ √L as base.
V = Speed in knots.
L = Length on water-line, in feet.

Data of Vessels.	Length. Ft.	Breadth. Ft.	Draught. Ft.	Displacement.
German Torpedo Boat Destroyer	207.7	22.00	8.9	350 tons
Danish Torpedo Boat "Makrelen"	140.0	14.25	7.0	118 tons
" " " "	140.0	14.25	6.6	105 tons
Danish Torpedo Boat "Söbjörnen"	145.5	15.5	7.6	132 tons
Italian Torpedo Boat Model	12.33	1.35	.32	145.2 lbs.

Draft is Draft Aft, except for Italian Model, for which it is Mean Draft.

*A lengthy abstract of this treatise was given in Engineering News of Feb. 23, 1905.

nite speed, while there will be a last hollow at a speed where the first bow wave hollow is found under the first stern wave crest, say, at a speed of $2\sqrt{L}$ to $2.2\sqrt{L}$.

In practice the waves set up by a ship do not have crests perpendicular to the vessel, but the phenomena observed agree quite satisfactorily with the theory as above set forth. The hump at the speed $V = \sqrt{L}$ is usually a notable one, whereas the last hump is, both in theory and practice, drawn out over several knots, and hence often not so obvious. Fig. 1 shows a curve of resistance of a model in which the humps are perceptible. This being rather a small and fine model, the hump at $\sqrt{L}$ is not so pronounced as for large models of block coefficient greater than .625.

zia, Italy. These curves were given in a paper read before the Institution of Naval Architects in 1900, by Major Guiseppe Rota, R. I. N. In each case I have modified the curves as originally given, plotting them upon values of $\frac{V}{\sqrt{L}}$, where V is the actual speed in knots and L is the length of the vessel in feet. This enables results for boats of different lengths to be compared. I have also characterized the curves, not by the actual depth of the water in each case, but by the depth expressed as a fraction of the length of the vessel. The results are surprisingly consistent and concordant, and show very clearly that the observed phenomena for a full-sized vessel might be readily inferred from careful model experiments. Example, the propeller will be somewhere near the hollow of the bow wave, a position where its efficiency is at a minimum, since it is working in water moving aft under wave action, and is in a position analogous to a lever working against a yielding fulcrum. The result, of course, is to accentuate the hump of the I. HP. curves. At just about the speed where abnormal resistance develops, the efficiency of propulsion begins to fall off. Hence the indicated horse-power, which is directly proportional to the resistance, and inversely proportional to the efficiency of propulsion, rises more abruptly than the resistance curve. Compare, for instance, the shape of the resistance curves for the Italian model in Fig. 2, and the I. HP. curves for the Danish and German boats. From Fig. 2 I have taken off from each

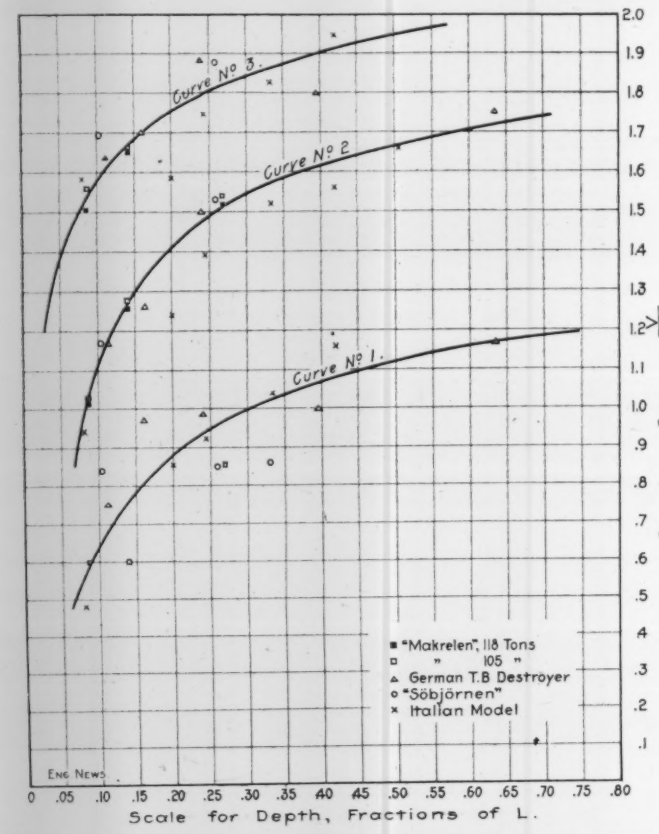


FIG. 3. CRITICAL SPEEDS OF TORPEDO VESSELS, FOR VARYING DEPTHS OF WATER.

(Deduced from the curves of Fig. 2.)

Curve 1.—Speed at which abnormal increase of resistance begins.
Curve 2.—Speed at which maximum excess of resistance occurs.
Curve 3.—Speed at which resistance again becomes normal or less than normal.

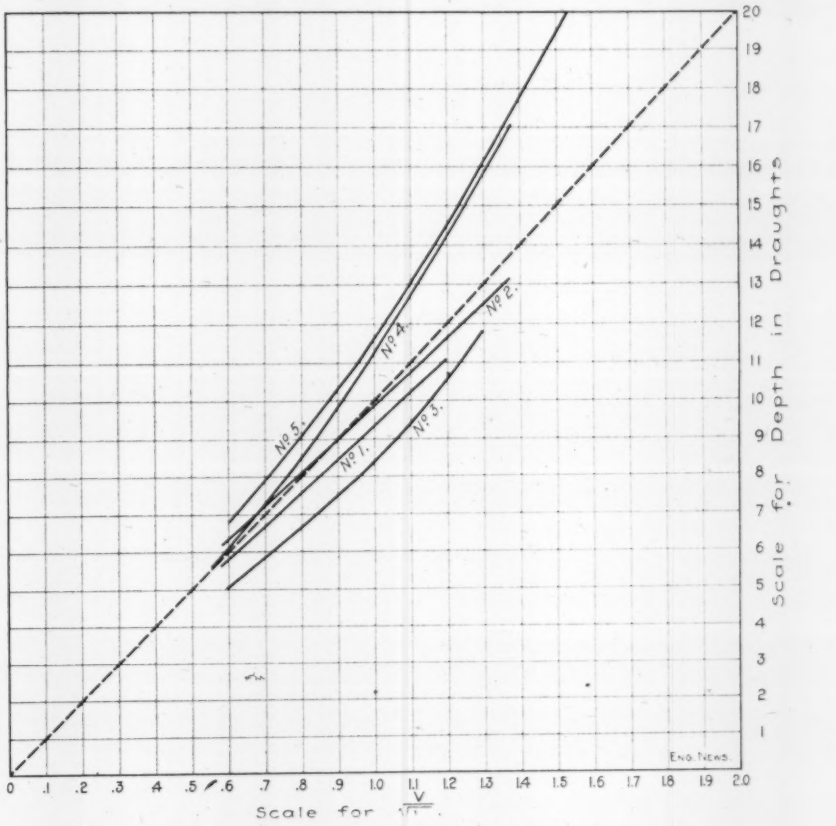


FIG. 4. DEPTHS OF WATER AT WHICH RESISTANCE BEGINS TO INCREASE.

For vessels of ordinary shape, after Rota's experiments. See Table II.
Depth expressed in Drafts, and plotted over $V \div \sqrt{L}$.

Curve 1.—12,000-ton vessel, 408 x 75.5 x 26.6 ft.
Curve 2.— 8,000-ton vessel, 385 x 67.0 x 21.4 ft.
Curve 3.— 6,000-ton vessel, 361 x 55.0 x 20.2 ft.
Curve 4.— 3,000-ton vessel, 380 x 40.3 x 13.8 ft.
Curve 5.— 1,000-ton vessel, 263 x 28.0 x 9.6 ft.

Now what happens in shallow water? Not only are both the bow wave and stern wave strengthened, but for a given speed each system has a longer distance from crest to crest than in deep water. That results in the humps appearing at a progressively lower speed as the water shallows. In the case of fine vessels, such as torpedo boats, the hump corresponding to $V = \sqrt{L}$ is too small to be noticeable. The only marked hump for such vessels is that corresponding to the speed, in deep water, $V = 1.5\sqrt{L}$ to $1.6\sqrt{L}$. As the water shallows, however, this hump not only becomes relatively greater, but appears at a much lower speed.

Experimental results have been published that supplement quite well the results of the recent German experiments. Fig. 2 shows on one diagram the results of the German experiments and results of similar experiments with two Danish torpedo boats, the "Makrelen" and the "Söbjörnen." The "Makrelen" data is from an article by Captain A. Rasmussen in "Engineering" of September 7, 1894, and the "Söbjörnen" data from a paper by the same author before the Institution of Naval Architects in 1899. On the same diagram are shown curves of resistance (not of horse-power) for a torpedo-boat model 12.33 feet long and of 145.2 lbs. displacement, as tried in water varying from one foot to ten feet in depth at the Experimental Model Basin at Spez-

ination of the various curves shows that in a depth of water corresponding to a given fraction of the length the perturbations occur at practically the same values of $\frac{V}{\sqrt{L}}$ in each case. In examining the curves with this in mind, it should be remembered that there are no two curves corresponding to exactly the same depth of water expressed as a fraction of the length, but the depths thus expressed approach one another sufficiently closely to enable the general accuracy of the above to be made obvious. The "Makrelen" curves are of peculiar interest, as they cover two different displacements of the same vessel. The increase of displacement has little or no effect upon the speeds at which the phenomena of perturbation occur, but for the trials in the two shallowest depths, particularly in the depth of .139 L, the maximum increased resistance is very much greater for the increased draft.

It is to be noted that the curves referring to the 12-ft. model are curves of resistance and not of horse-power. The curves of horse-power accentuate the features of the curves of resistance for the reason that the matter of the I. HP. required at a given speed is complicated by the efficiency of the machinery. It so happens that when the bow wave crest is sufficiently abaft the stern to reinforce to a maximum extent the natural stern

curve spots of value of depth expressed as a fraction of length and values of $\frac{V}{\sqrt{L}}$, at which

a. The increase in resistance or power becomes noticeable;

b. The increase is at a maximum;

c. The curve of resistance or power crosses the normal again.

The curves in Fig. 3, drawn somewhat arbitrarily through the spots, are seen to reasonably approximate the spots, particularly No. 2, which is of most practical importance. The only spots which do not follow very closely to No. 2 are the resistance curves of the model.

While Fig. 3 indicates on its face that it will probably give with sufficient accuracy for practical purposes the points of speed at which certain salient phenomena of shoal water resistance of vessels of the type to which it refers may be expected to appear, neither it nor Fig. 2 will shed much light in advance upon the actual increase of power to be anticipated in a given case. From careful model experiments only could we estimate in advance with any approach to reliability the increase of power required to drive a given vessel at a given speed in shoal water as compared with deep.

Moreover, Figs. 2 and 3 refer only to vessels relatively long, of fine block coefficients, and

driven to excessive speeds. The subject of vessels of less extreme type is of perhaps greater practical importance. Such vessels generally show a serious hump in the resistance at a speed $V = \sqrt{L}$, and are seldom powered high enough to surmount this hump even in deep water. Evidently, then, in shallow water such vessels will simply show an increase in resistance, and their I. HP. curves would never be found falling off again toward the normal or deep water curves. The depth at which the increase of resistance becomes appreciable for such vessels is a matter of much interest and importance.

The most complete experimental investigation on this subject of which results have been published will be found in the paper by Major Rota, previously referred to. From the results of model experiments he has deduced Table II. below, giving the minimum depth for no change of resistance of five vessels.

TABLE II.—MINIMUM DRAFT IN FEET FOR NO CHANGE IN RESISTANCE.

After Rota.

Model.	(1)	(2)	(3)	(4)	(5)
Displacement, tons	12,000	8,000	6,000	3,000	1,000
Length, ft.	408	385	361	380	263
Breadth, ft.	75.5	67	55	40.3	28
Mean draught, ft.	26.6	21.4	20.2	13.8	9.6
Speed, knots, 12.	154	138	108	89	75
" 14.	177	158	125	115	92
" 16.	200	177	145	125	118
" 18.	223	197	161	141	125
" 20.	246	214	181	161	145
" 22	270	233	204	184	164
" 24.	....	253	230	204	184
" 26.	....	.. .	....	227	204

If the depths given in Table I. are expressed as multiples of the draft in each case, and then plotted over values of $V \div \sqrt{L}$, we obtain Fig. 4, the five curves which pertain to the five models. Of course, theoretically, the minimum depth at which absolutely no change in resistance occurs is an infinite depth. An examination of Major Rota's paper shows that the minimum depths given by him are quite liberal, and could be decreased 10% or 15% in practically every case without involving material increase in resistance. The dotted straight line in Fig. 4, if H denotes the draft of the ship, corresponds to the formula,

$$\text{Depth} = 10\,\text{H.} \times \frac{V}{\sqrt{L}}.$$

Up to speeds equal to $\sqrt{L}$ this formula adequately represents the results of Rota's experiments. It appears probable that for all vessels of ordinary type it would be found satisfactory. For vessels pushed to high speeds, however, particularly vessels of shallow draft, this formula fails, and for such vessels it would be necessary to use Fig. 3. It would be very desirable if the experiments made by Major Rota were repeated with a large number of varying types of models, in order to enable final conclusions to be drawn on this interesting subject.

There are also some puzzling features in the figures I have given which could be cleared up by further experiment. The curves of the Italian model in Fig. 2 extend to a higher relative speed than the others, and it will be noted that at the high speeds the resistances vary as depth, that is to say, the deeper the water the greater the resistance. The horse-power curves of the full-size boats clearly tend in the same direction. There seem to be two possible explanations of this obvious fact. It was pointed out above that in the deep water curves of resistance, beyond the hump which begins to show strongly at about $V = 1.5\sqrt{L}$ or $V = 1.6\sqrt{L}$, there is a hollow in the curve. The shallower the water the lower the speed at which both hump and hollow appear, and it may be that, as we shoal the water at a given high speed, we get more and more benefit of the last hollow following the last hump, unless the high speed is beyond the natural position of the deep water hollow. Another theory is that in shoal water at high speeds the waves formed tend to depart more from the trochoidal system than at low speeds, and to approach the so-called "solitary" wave of translation, which is not followed by a series of other crests and requires less energy to maintain than a trochoidal system. The "solitary" wave of translation is a well-known phenomenon in canals, but could probably not maintain itself long in wide water. Model experiments in shallow water pushed to speeds $\frac{V}{\sqrt{L}} = 3$ or over would settle the above point.

In conclusion, I should like to point out that there is no theory extant as to why the observed perturbations of resistance should occur in such deep water. With a trochoidal system of waves the difference between a system in infinite depth and in water as deep as half the wave length is infinitesimal. This applies to a system of waves which has been set up long enough to allow the deepest particle of water to be effected. Ten years ago, in a paper before the Institution of Naval Architects, I demonstrated that upon the stream line theory for a reasonably ship-shaped form deeply submerged the disturbances of pressure and velocity at a distance corresponding to ten times the draft of a ship were too small to take account of. My conclusion at that time was that in water of depth ten times the draft of the ship no perturbation of resistance was to be expected. This seems to have been the accepted theory of the German authorities prior to the experiments referred to. It appears necessary to conclude that, useful and reliable in some respects as is the trochoidal theory of waves applied to waves set up by vessels, this theory fails in shoal water.

Both the trochoidal theory of waves and the stream line theory of the flow of water assume that the water is a perfect fluid and that the surfaces past which it flows are frictionless. These assumptions are, of course, not in strict accordance with the fact, and it is possible that the resulting errors, negligible in deep water, assume greater and greater importance as the water shoals.

THE FIRST CONNECTION BY PRECISE LEVELING BETWEEN THE ATLANTIC AND PACIFIC OCEANS.

By John F. Hayford.*

On October 4, 1904, a Coast and Geodetic Survey party, running eastward from Seattle, Washington, met a similar party, running westward, at Hunt's Junction, in the southeastern part of Washington. The party running from east to west had started in the beginning of the season from a bench mark of which the elevation had been fixed by a long line run during several seasons and extending westward from the precise level net, composed of many circuits, which covers the eastern half of the United States. As far west as Norfolk, Nebraska, the elevations in this net had been checked by completed circuits of precise leveling of the highest grade of accuracy. The joining of the two lines at Hunt's Junction completed the first connection by precise leveling between the Atlantic and the Pacific.

The discrepancy developed at the junction was 0.615 ft. (= 187.5 millimeters), the Pacific being apparently higher than the Gulf and Atlantic.

The old question at once arises: Is the Pacific at a different elevation from the Atlantic? The discrepancy of 0.615 ft. must be due either to errors in the tidal observations which furnished the connection with mean sea level, or errors in the leveling, or to a real difference in the elevation of the mean sea surface at the points at which the tidal observations were made.

The three principal connections with sea level concerned are at Sandy Hook, near New York City; at Biloxi, Mississippi; and at Seattle, Washington. Six years of tidal observations were taken at Sandy Hook and five years at each of the other points. The range in the six annual means at Sandy Hook was 0.322 ft., and of the five annual means at the stations at Biloxi and Seattle was, respectively, 0.100 and 0.204 ft. These ranges are not sufficient to account for the discrepancy of 0.615 ft.

The shortest line of leveling of the highest grade of accuracy from Seattle to Sandy Hook is 4,600 miles (7,400 kilometers); to Biloxi, 3,500 miles (5,700 kilometers); and to Norfolk, the point at which the line to the westward leaves the thoroughly checked portion of the precise level net, is 2,000 miles (3,300 kilometers).

If it is assumed that the discrepancy (.615 ft.) is simply an accumulated error in leveling and the rate of accumulation is assumed to be uniform between Seattle and Biloxi, it is at the rate of one foot in 5,700 miles (.033 millimeters per kilometer). Even if it is assumed that the accumulation all occurred between Seattle and Norfolk, it is at the rate of one foot in 3,300 miles (.057 millimeters per kilometer). This is an extremely small error of leveling.

Another test to determine whether the discrepancy is a possible error of the leveling may be applied. The probable error of the elevations at Seattle, as carried westward from the Gulf and Atlantic, the computation being based upon the discrepancy developed in the circuits in the eastern part of the United States, was ± 76 millimeters. The actual discrepancy is two and one-half times this. According to the doctrine of chances, such a discrepancy, two and one-half times the probable error, should occur about once in ten times.

Therefore, it is not safe to make the statement that the Pacific is higher than the Gulf and Atlantic; the extremely small discrepancy being well within the possible limits of error of the precise leveling alone, even though it be assumed that the leveling in question is of as high a grade of accuracy as any yet done anywhere in the world.

One is apt to associate observations of such extreme accuracy as this precise leveling with slow progress and high cost. It is interesting, therefore, to note that 3,000 miles out of the 3,500 between Seattle and Biloxi, have been leveled since the beginning of the field season of 1899, and that the average rate of progress, during the period 1900-1904 (a total of 3,900 miles) with the new type of precise level* now in use in the Coast and Geodetic Survey, was 64 miles of completed line per month, for each observer, and that the average cost, per completed mile, was $10; including salaries, transportation and bench marks. Each completed mile was leveled over at least twice, and, in some cases, four or more times. This rate of progress is comparable with that ordinarily secured in wye leveling, which is of a much lower order of accuracy.

*Inspector of Geodetic Work and Chief of Computing Division, Coast and Geodetic Survey.

THE COST OF FREIGHT CARRIAGE BY CARAVAN in Oriental countries, on the backs of camel or other beasts of burden is a matter on which actual figures are seldom seen in print. We find in a recent report of U. S. Consul John Tyler, of Teheran, Persia, a statement of the rates charged for carrying freight in Persia over the road from Ahwaz to Ispahan, 270 miles. The former town is located on a river emptying into the head of the Persian Gulf, while Ispahan is an inland city of some 80,000 inhabitants. The average time by caravan for the journey of 270 miles is 24 days, or an average of 11 miles per day, the charge for carrying goods per 13 lbs. weight is 24.41 cts. from Ahwaz to Ispahan and 13.43 cts. from Ispahan to Ahwaz. These figures are equivalent to 14 cts. per ton-mile in one direction and 7.7 cts. in the opposite direction where the traffic is light and freighters are glad to accept any figure to help pay the expenses of their return journey. It will be seen that the former figure is much below the 25 cts. per ton-mile which is generally accepted in the United States as the standard cost of hauling freight by wagon with animal traction.

DISINTEGRATION OF PORTLAND CEMENT BRIQUETTES BY OIL AND EXPERIMENTS TO PREVENT IT.

By James C. Hain,† Assoc. M. Am. Soc. C. E.

In January, 1903, it was accidentally discovered in the cement testing laboratory of the Chicago, Milwaukee & St. Paul Ry. (Mr. C. F. Loweth, Engineer and Superintendent of Bridges and Buildings) that oil disintegrates Portland cement. Briefly, the circumstances were as follows: A two-year-old neat Portland cement briquette which had been in use in the laboratory as a paper-weight was laid aside, where it was exposed to occasional drippings of signal oil. In ten months the briquette began to disintegrate. Photograph No. 1 shows the effect after being exposed as above for that period.

Up to this time (two years ago) there was considerable difference of opinion in regard to the effect of oil on concrete. In fact, it exists to-day.

*See Engineering News of July 2, 1903, pp. 2 to 4.
†Engineer of Masonry Construction, Chicago, Milwaukee & St. Paul Ry., Chicago.

Many consider oil entirely harmless, and to prove their assertions call attention to machinery foundations in use for many years, which, though exposed to waste oil, are perfectly sound. On the other hand, there are many who believe the contrary to be true, and tell about concrete disintegrating where oil appeared to be the sole cause. The laboratory test above referred to proves clearly that oil must have a powerful effect on concrete mortar to disintegrate a two-year-old briquette. It, therefore, seemed of great value to make further investigations, because concrete is used extensively in places where waste oil cannot be avoided, such as engine and machine foundations, turntable and roundhouse pits, drawbridge piers and abutments, floors in oil storage houses, etc. The result of the discovery referred to indicates that concrete when used where oil can reach it may disintegrate in time, and thus result seriously.

Consequently, we started an investigation. An examination was made of a great many concrete structures on which more or less oil was found. There was a limited number of instances where it possibly was affected by oil. In these cases, however, the concrete was very old, and the character of the original material and the workmanship was questionable. On the other hand, no concrete which was built in late years, and known to be of good quality, was affected to any perceptible degree. One case which particularly attracted our attention was the concrete floor of an oil house in which lubricating and lighting oils had been stored for six year without any apparent effect. The penetration of the oil was slight, perhaps not to exceed 1-16-in. Moreover, the saturated portion seemed to be as sound as the rest. There were other cases where the oil had penetrated deeper. For example, in the pits of a roundhouse, the oil had gone in from ¼-in. to ½-in. In other respects, the concrete seemed perfectly natural. These pits, however, had been in use only about a year when investigated. It will thus be seen that our observations of concrete structures proved nothing definite. While the investigation seemed favorable for the structure examined, it could not be taken as conclusive for all concrete structures.

We then decided upon laboratory experiments. These tests consisted of Portland cement briquettes, made of neat cement, 1:3 of sand and 1:3 of limestone screenings, which were allowed to age four days in the laboratory air, and were then subjected to applications of signal oil. (See "First Series," "Table I.") At first, small quantities of oil (enough to saturate) were applied daily. Later the applications were less frequent, depending upon the amount the briquette absorbed. Cracks developed in the sand and limestone briquettes first. They appeared in these at the age of 2½ months. The effect is seen in photograph No. 2. The neat briquettes showed similar results in five months. A sand briquette of the same series is shown in photograph No. 3, at the age of six months, when larger cracks had developed. Photograph No. 4 is the same briquette after crushing in the hand, thus showing the disintegration to be complete. All the briquettes eventually disintegrated.

After being convinced of the results of the above, a still more extensive series was started. Previously tests were confined to one oil (signal) and a single cement. This "Second Series" (see Table I) included a characteristic oil or fat from each of five different groups which are most common, and one each of the three varieties of cement in which they may be classed according to the raw material from which they are manufactured. The oils and fats used were as follows:

			—Vegetable Oil.—		
Class..	Animal Fat.	Animal Oil.	Semi-drying.	Drying.	Mineral.
Kind..	Ext. of Lard.	Whale.	Castor.	Boiled Linseed.	Crude Petroleum.

In addition to these, signal oil (which is a mixture of animal fat and mineral oil) was also used because it served for a comparison with the previous tests. In choosing the cement, a well-known brand of Portland cement was selected from those manufactured from stone and clay, another from marl and clay, and the third from slag and stone.

Neat and 1:3 sand briquettes from all these varieties of cement were then made, and treated each with the six different kinds of oils and fats. A total of about 800 briquettes were required to cover the entire series of tests (including those made for comparison but not treated with oil). All briquettes were left in the laboratory air seven days before starting the oil treatment, which was similar to that used in the former test. The oil applications were continued until the tests ended, nine months after they were started. Tensile tests were obtained of the oil-treated briquettes and also (for comparison) of two similar sets without oil, one of which was kept in water, and the other in laboratory air. The briquettes were broken at 28 days, and 3, 6 and 9 months, except when disintegration prevented.

In regard to the results; I will not take the space to reproduce the tensile tests. All other information regarding them is shown in Series II. of Table I. It will suffice to discuss the most important features. The greatest effect was caused by animal fat or extract of lard oil. It disintegrated most of the neat and sand briquettes in from 2 weeks to 2½ months. However, it failed to destroy some, even at the end of nine months, when the tests were discontinued. As a rule, the neat briquettes were affected first, which was contrary to what was noticed in the first series of tests. Photographs 5, 6 and 7 show the results of the lard-oil treatment on the nine-months'-old briquettes of all three varieties of cement. It will be seen that the stone-clay class was disintegrated the least and the slag-stone the most. The above order of disintegration, however, was not followed in all cases. The materials out of which a cement is made do not seem to govern the effect of the oil; instead, the peculiar characteristics of each cement apparently regulate that. Next in effect was signal oil, a mixture of animal fat and mineral oil. It acted only slightly differently from the extract of lard. Following this was the whale and castor oil. They caused considerably less disintegration than either of the two before mentioned. Only a small percentage of the briquettes treated with these oils were affected in outward appearance up to the end of the test. The two remaining oils, petroleum and boiled linseed, did not disintegrate any of the briquettes up to nine months. Petroleum, however, penetrated and affected the strength somewhat, and possibly would have eventually destroyed it, while boiled linseed formed a coating without penetrating. Of the five classes, boiled linseed was the only one that apparently did not affect the strength of the briquettes. This, no doubt, was due to oxidation which prevented it from soaking in. Had it not dried before penetrating, it possibly would have disintegrated the briquette to the same extent as castor, the other vegetable oil used.

We have not seen the effect of oil on the weaker briquettes. I say weaker, because it will be remembered that the first series of tests which consisted of only a few, were treated with oil after four days, and the second longer series after seven days. Also, that these were not regularly-cured briquettes, but exposed to the laboratory air instead of water after making. This method was used to allow the briquettes to dry so they would more readily absorb the oil. Therefore, their age when the oil was first applied, and the method of curing naturally made these briquettes more susceptible to oil than if they were older and cured in water. This was intended, in order to make the effect of the oil treatment more pronounced. To supplement the tests on these weaker briquettes, experiments were made with older ones which were cured according to the regular laboratory practice. Some of these tests follow: A neat, a 1:1, a 1:2 and a 1:3 sand briquette, all of which were two years old, were dried at the stove for 20 days and then treated with signal oil. It has been practically two years since the oil was first applied. With one exception they show no signs of disintegration, and this was only noticeable recently. The above briquettes were made of silica cement instead of regular Portland,

TABLE I.—EFFECT OF OIL ON PORTLAND CEMENT BRIQUETTES. February, 1905.

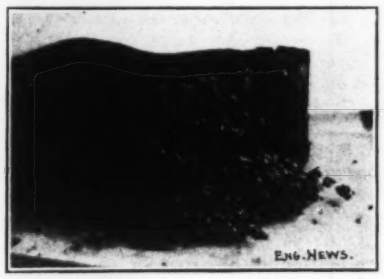
Date Made.	Class of Portland Cement.	Briquettes (Portland Cement.	Method of Curing Briquette. In water.	In laboratory air.	Dried in warm air.	Oil —Applications.— Age when started.	Time applied to date (where not disintegrated).	Extract Lard —Oil.— No. briq. made.	Time applied before disintegrated.	Whale —Oil.— No. briq. made.	Time applied before disintegrated.	Castor —Oil.— No. briq. made.	Time applied before disintegrated.	Linseed Oil —(Boiled).— No. briq. made.	Time applied before disintegrated.	Petroleum Oil —(Crude).— No. briq. made.	Time applied before disintegrated.	Signal —Oil.— No. briq. made.	Time applied before disintegrated.
ORIGINAL DISCOVERY.																			
Jan., 1900	Stone and clay	Neat	....	2 yrs.	....	2 yrs.	....	....	....	....	....	....	....	....	....	....	....	1	10 mos.
AGED BRIQUETTES—REGULAR TREATMENT.																			
Feb., 1901	Silica cement made by grinding together equal parts of cement (sand and clay class) and sand.	Neat	2 yrs.	....	20 days	2 yrs.	2 yrs.	....	....	....	....	....	....	....	....	....	....	1	Sound.
Feb., 1901		1 to 1	2 yrs.	....	20 days	2 yrs.	2 yrs.	....	....	....	....	....	....	....	....	....	....	1	Sound.
		1 to 2	2 yrs.	....	20 days	2 yrs.	2 yrs.	....	....	....	....	....	....	....	....	....	....	1	Sound.
		1 to 3	2 yrs.	....	20 days	2 yrs.	....	....	....	....	....	....	....	....	....	....	....	1	2 yrs.
ODD TESTS.																			
Sept., 1902	Stone and clay	Neat	28 days	3 mos.	....	4 mos.	....	....	....	....	....	....	....	....	....	....	....	1	8 mos.
Feb., 1903	Marl and clay	Neat	....	1 mo.	....	1 mo.	....	....	....	....	....	....	....	....	....	....	....	1	6 mos.
FIRST SERIES.																			
Mar., 1903	Stone and clay	Neat	....	4 days	....	4 days	....	....	....	....	....	....	....	....	....	....	....	18	5 mos.
Mar., 1903	Stone and clay	1:3 sand	....	4 days	....	4 days	....	....	....	....	....	....	....	....	....	....	....	18	2½ mos.
Mar., 1903	Stone and clay	1:3 limestone screenings	....	4 days	....	4 days	....	....	....	....	....	....	....	....	....	....	....	18	2½ mos.
SECOND SERIES.																			
Jan., 1904	Stone and clay	Neat	....	7 days	....	7 days	....	18	3 mos.	18	*	18	*	18	*	18	*	18	*
Jan., 1904	Stone and clay	1:3 sand	....	7 days	....	7 days	9 mos.	12	*	12	*	12	*	12	*	12	*	12	*
Jan., 1904	Marl and clay	Neat	....	7 days	....	7 days	....	18	2⅔ mos.	18	*	18	*	18	*	18	*	18	6 mos.
Jan., 1904	Marl and clay	1:3 sand	....	7 days	....	7 days	9 mos.	12	*	12	*	12	*	12	*	12	*	12	*
Jan., 1904	Slag and stone	Neat	....	7 days	....	7 days	....	18	1 mo.	18	3 mos.	12	4 mos.	18	*	18	*	18	1¼ mos.
Jan., 1904	Slag and stone	1:3 sand	....	7 days	....	7 days	....	12	7 mos.	12	4¼ mos.	12	6½ mos.	12	*	12	*	12	4 mos.
Grand total briquettes, 600.			Total briquettes.....					90		90		90		90		90		150	

* Sound after applying Oil 9 Mo. at which time tests were discontinued.

which consisted of equal portions of sand and Portland cement, ground together to a fineness that passed through a No. 200 sieve. In other words, these briquettes are weaker than the standard Portland cement briquettes of the same mixture. The one that failed was the weakest of the four, being a mixture of 1 of silica cement to 3 of sand. Again, a neat and a 1:3 sand briquette were taken from the vat at the age of one year and treated with signal oil. They appear to be perfectly sound, though soaked in oil for practically one year. Still another specimen was a 28-day neat briquette, which was dried by exposing it to laboratory air for three months. Signal oil was then applied. At the age of eight months the briquette was disintegrated. Eight one-year-old briquettes were also included in this series. They are sound. However, they were immersed in oil only nine months, and, moreover, were otherwise treated to prevent the action of the oil. (Of these I will speak later.) In connection with this series of older briquettes, we are experimenting with a piece of concrete from the oil-house floor before mentioned, which, though in use for six years, was not perceptibly effected. This piece of concrete has now been immersed in oil for ten months and is still sound. It will thus be seen that only two briquettes failed out of the long-time series of 15; both of these the weakest in the lot. One was 28 days old when taken from the vat, which, if an average briquette, would have broken at from ¾ to ⅞ of its ultimate strength. The other, while set for two years in water, was a comparatively lean mixture, being made of 1 part of silica cement and 3 parts of sand. (This briquette would have broken at from ¾ to ⅞ of the strength of a 1:3 regular Portland.) The specimen of concrete and the rest of the briquettes show no signs of failure. However, the oil has penetrated throughout, and also possibly weakened them.

Thus far, our investigation may be summarized briefly as follows: At the outset we failed to find a specimen of concrete that we felt was positively disintegrated by oil, though we not infrequently heard of it. For example, the pedestal under a cream separator, which case seemed possible because it is an instance of almost continued application of animal fat, apparently the worst condition that could exist. On the other hand, plenty of concrete was found that oil had penetrated but not disintegrated. Further, our tests on comparatively new briquettes, which were weakened by exposure to air, showed that with one exception they were disintegrated by all classes of oils and fats. These oils and fats, when arranged according to their effect (as far as our experiments indicate), are as follows: 1, animal fat; 2, animal oil; 3, vegetable oil, and 4, mineral oil. The exception to the above was the drying vegetable oil, which, unlike the semi-drying, oxidized before penetrating. It was apparently the only one which had no effect. In these tests animal fat had a much greater effect than the oils. At the end of the tests, or nine months after the first application, only a small percentage of the briquettes were disintegrated by the oils which contained no fat. Our tests, however, are not extensive enough to show whether the above arrangement of the classification of fats and oils according to their effect on briquettes would hold true if other oils had been experimented with, because their chemical compositions vary so much. And last, out of 15 old briquettes which were seasoned according to the laboratory practice, only two have been outwardly affected, though treated from nine months to two years. These two were the weakest, as before pointed out. The briquettes which remained unaffected were cured from one to two years in water. Though only two of the fifteen have been destroyed by oil, all have been penetrated, and also possibly will fail in time.

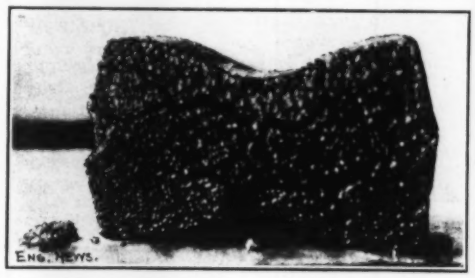
With all this in veiw, we are still in the dark as to the possible final effect of fats and oils on concrete structures. On the following points, however, we are reasonably certain: (1) Most oils penetrate concrete mortar, which makes them dangerous. (2) Concrete is more liable to be disintegrated when saturated with oils and fats if



No. 1.
Disintegrated by Signal Oil. Three years old. Neat Portland cement. Oil applied for 10 months. Previously used for paper weight.

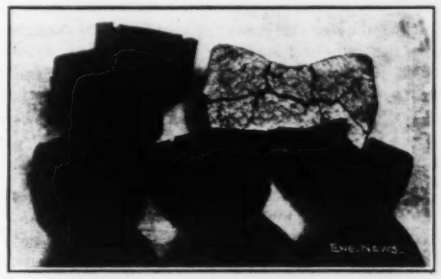
No. 2.
Disintegrated by Signal Oil. 2½ months old. Portland cement briquettes. 1:3 sand and 1:3 limestone screenings. Four days old in air before oil was applied.

No. 5.
Disintegrated by Extract of Lard Oil. Nine months old. Portland cement (stone and clay). Neat and sand briquettes. Seven days old in air before oil was applied. Began failing in 2½ months.

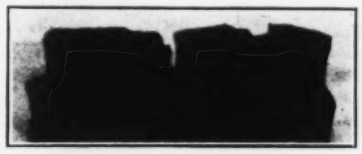


No. 3.
Disintegrated by Signal Oil. Six month old. Portland cement and sand 1:3. Four days old in air when oil was applied.

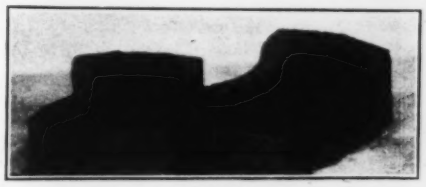
No. 4.
Disintegrated by Signal Oil. Crumbled in hand. Six months old. Portland cement and sand 1:3. Four days old in air when oil was applied.



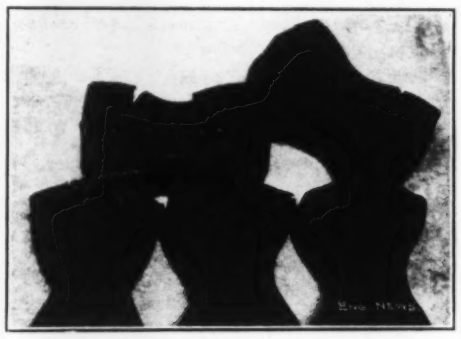
No. 6.
Disintegrated by Extract of Lard Oil. Nine months old. Portland cement (marl and clay). Neat and sand briquettes. Seven days old in air before oil was applied. Began failing in two months.



No. 8.
Six months old briquettes (treated). Made up with alum (5%) soap (7%) solution instead of water. Portland cement (marl and clay). Neat and sand briquettes. Seven days in damp box, 7 days in air. Extract of Lard Oil then applied. Began failing in 40 days.



No. 10.
Six months old treated briquettes. Made up with alum (5%) soap (7%) solution instead of water. Portland cement (marl and clay). Neat and sand briquettes. Seven days in damp box, 7 days in air. Signal Oil then applied. Began failing in from 3 to 4 months.



No. 7.
Disintegrated by Extract of Lard Oil. Nine months old. Portland cement (slag and stone). Neat and sand briquettes. Seven days in air before oil was applied. Began failing in one month.

No. 9.
Six months old untreated briquettes (for comparison to No. 8). Portland cement (marl and clay). Neat and sand briquettes. Seven days in damp box, 7 days in air. Extract of Lard Oil then applied. Began failing in 15 to 20 days.

No. 11.
Six months old untreated briquettes (for comparison with No. 10). Portland cement (marl and clay). Neat and sand briquettes. Seven days in damp box, 7 days in air. Signal Oil then applied. Began failing in 1½ months.

SAMPLES OF CEMENT BRIQUETTES EXPOSED TO OILS IN CEMENT-TESTING LABORATORY OF THE CHICAGO, MILWAUKEE & ST. PAUL R. R.

Classification of Fats and Oils in Which Only the More Common Primary Fats and Oils Are Given.

- Solid fats
  - Vegetable
    - Palm oil.
    - Cocoanut oil.
  - Animal
    - Goose fat.
    - Lard and lard oil.
    - Beef marrow.
    - Tallow and tallow oil.
    - Beef and mutton tallow.
- Oils or liquid fats
  - Vegetable oils
    - Drying
      - Linseed oil.
      - Hemp and poppy seed oil.
      - Tobacco oil.
    - Semi-drying
      - a—Cotton seed oil.
      - b—Mustard oil Rape oil.
      - c—Castor oil.
    - Non-drying
      - Olive oil.
  - Animal oils
    - Marine
      - Fish—Sardine, Liver — Cod and shark.
      - Blubber—Seal and whale, dolphin and porpoise.
    - Terrestrial
      - Sheep's foot.
      - Horse's foot.
- Mineral oil—Crude petroleum
  - Naphtha
    - Gasoline.
    - Benzine.
  - Illuminating oils
    - Kerosene.
    - Petroleum.
    - Paraffine.
  - Lubricating oils.
  - Paraffine Wax.
  - Vaseline.

not thoroughly set. (3) A good quality of concrete is less susceptible to the effect of oil than a poor quality, such as a porous, frosted, lean, poorly mixed, or improperly seasoned concrete. (4) Ordinary concrete work is rarely subjected to continued large doses of oils. It is more often only occasionally spattered. Disintegration under the latter conditions seems remote, especially in the case of first class, well seasoned concrete. The concrete floor above mentioned is an excellent example; the oil spattered on it perhaps was oxidized or absorbed by the dust, and instead of penetrating, helped to protect it. Last, even though subjected to the equivalent of continued saturation, the disintegration would be long drawn out if the concrete were properly made and well set. Our conclusions may eventually be altered, though it must necessarily be a long time before definite results will be obtained from the tests under way. In the meantime, more experiments will be started, especially on concrete of poor quality, and also tensile tests on well-seasoned briquettes.

Table I. shows the effect of oils on Portland cement briquettes, which I have just discussed. A study of it will perhaps reveal more than has been said. It does not include the tensile tests or the untreated briquettes which were made for comparison.

Attention is also called to the more complete classification of fats and oils, shown herewith. The subdivisions are made from a physical and chemical standpoint. In the latter respect, however, the classification is not as good as the former, because the chemical compositions of oils differ largely, even in the same subdivision. Only the more common primary fats and oils are given. The varieties are many. It can thus be seen that a wide range of experiments is desirable to cover the entire field. This is all the more necessary because of the chemical differences before spoken of.

We have now seen the effect of oil, next we are naturally interested to know what will prevent it. Even under ordinary conditions, it seems very desirable to use a wash for oil-spattered concrete that will prevent oil from penetrating. It is also possible that concrete seasoned according to ordinary practice will not resist oil as well as the water-cured briquettes. Most of all to be protected are oil-spattered structures of reinforced concrete. Whereas in these cases the strength depends entirely upon the quality of the concrete, we cannot afford to take chances. It would then be a great relief if some simple wash could be applied to protect it from oils. While experimenting with the effect of oils, we made several attempts to discover something that would answer the purpose. Our attention was first attracted to linseed oil. This, as already noted, did not penetrate, but formed a coating on the outside of the briquette which apparently protected it. However, after two months' application of signal oil, the linseed oil was penetrated, and later the briquette was disintegrated. Other oils are slower in their action on linseed oil.

Another experiment was made with alternate washes of a 5% solution of alum and a 7% solution of castile soap, which is known as Sylvester's process of making concrete impervious to water. The combination of the two forms an insoluble precipitate which fills the voids. Five washes of each were applied alternately. The coating failed to prevent the oil from attacking the mortar. These same solutions were also tried in a different way. The briquettes were made with them instead of water. One solution was first thoroughly mixed with the cement, the other solution added and then molded into a briquette. When treated with oil, these proved inferior to those made by the other method. Moreover, the briquettes broke about 20% below the untreated, which weakening is contrary to what has been claimed for the process. Photograph No. 8 shows briquettes which were made according to this process, and after 14 days' old, treated for six months, with extract of lard oil. Photograph No. 9 shows briquettes of the same series which were made in the regular way. Photographs 10 and 11 are similar, except that signal oil was used in place of extract of lard.

We next experimented with paraffine, because there are few things that attack it, including all acids and alkalies. I believe I am right in also saying that the obelisk in Central Park, New York, was treated with it to prevent weathering. Part of the briquettes were coated with it on the outside by dipping them in hot paraffine, and other briquettes were heated and held in hot paraffine until they became penetrated ⅛-in. Neither of these experiments apparently prolonged the time before disintegration by oils. The results were a great disappointment.

Sodium silicate, or what is known as water glass, was the last tried. This is a fireproof oil or varnish, and is sometimes used to prevent stone from weathering. This coating was dissolved in 20 days. One of the briquettes has been disintegrated, although the oil has been applied for only 1½ months.

Table II. covers the tests on the briquettes which were treated to preserve them from the effects of oil. A study of it will reveal more than has been pointed out in the paper. It contains full information about all of these tests.

The difficulty experienced in finding a cheap wash that will absolutely protect concrete from oil is apparent. Something is wanted that will penetrate into the concrete to allow for wear, and (most of all) be inexpensive. This paper should bring the matter to the attention of engineers and concrete users, and start further investigations along these same lines, or at least bring out suggestions that can be tried in established laboratories. It is to be hoped that the time is near when it will not be necessary to use brick facing and stone caps for massive concrete exposed to oil, or in the absence of these to feel uneasy about the durability of the concrete. Moreover, we do not want to limit the use of reinforced concrete to those places where there is no oil.

In closing, I wish to say that we greatly appreciate the work of our cement tester, Mr. Geo. J. Griesenauer, in furthering these investigations.

TABLE II.—EFFECT OF SIGNAL OIL AND EXTRACT OF LARD OIL ON PORTLAND CEMENT BRIQUETTES TREATED TO PRESERVE THEM. February, 1905.

Date Made.	Class of Portland Cement.	Method of Curing briquettes. In laboratory air.	In damp air.	In water.	Dried in warm air.	Time treated with preservative.	Oil Applications. Age when started.	Time applied to date (when not disintegrated).	Signal Oil. Neat Briq. No. briq. made.	Signal Oil. Neat Briq. Time applied before disintegrated.	Signal Oil. 1:3 Sand Briq. No. briq. made.	Signal Oil. 1:3 Sand Briq. Time applied before disintegrated.	Extract of Lard Oil. Neat Briq. No. briq. made.	Extract of Lard Oil. Neat Briq. Time applied before disintegrated.	Extract of Lard Oil. 1:3 Sand briq. No. briq. made.	Extract of Lard Oil. 1:3 Sand briq. Time applied before disintegrated.
SYLVESTER'S PROCESS I.—5% alum and 7% soap solution. Five coats began dissolving in 15 days.																
June, 1903	Stone and clay	....	....	1 yr.	14 days	1 day	1¾ yr.	9 mos.	1	Sound	1	Sound	1	Sound	1	Sound
Regular briquettes to accompany above.																
June, 1903	Stone and clay	....	....	1 yr.	14 days	1 day	1¾ yr.	9 mos.	1	Sound	1	Sound	1	Sound	1	Sound
LINSEED OIL.—This oil oxidized and formed a hard coating. Above oils dissolved coat.																
Jan., 1904	Stone and clay	6 mos.	....	....	....	6 mos.	6 mos.	8 mos.	1	Sound	1	Sound	1	Sound	1	Sound
Jan., 1904	Marl and clay	6 mos.	....	....	....	6 mos.	6 mos.	8 mos.	1	Sound	1	Sound	1	Sound	1	Sound
Jan., 1904	Slag and stone	6 mos.	....	....	....	6 mos.	6 mos.	8 mos.	1	2 mos.	1	Sound	1	2 mos.	1	Sound
SYLVESTER'S PROCESS II.—Briquettes made up with 5% alum and 7% soap solution instead of water.																
June, 1904	Marl and clay	7 days	7 days	....	....	....	14 days	....	3	4 mos.	3	5 mos.	3	45 days	3	38 days
Regular briquettes to accompany above.																
June, 1904	Marl and clay	7 days	7 days	....	....	....	14 days	....	3	1½ mos.	3	1½ mos.	3	15 days	3	20 days
PARAFFINE I.—Applied hot to cold briquette. Coated only. Oils dissolved coating in 1½ month.																
Sept., 1904	Stone and clay	14 days	....	14 days	....	1 day	28 days	4 mos.	1	Sound	1	2 mos.	1	Sound	1	2 mos.
Sept., 1904	Marl and clay	14 days	....	14 days	....	1 day	28 days	4 mos.	1	Sound	1	2 mos.	1	Sound	1	2 mos.
Sept., 1904	Slag and stone	14 days	....	14 days	....	1 day	28 days	4 mos.	1	Sound	1	2 mos.	1	Sound	1	2 mos.
PARAFFINE II.—Applied hot to heated briquette. Penetrated ⅛ inch. Oils dissolved paraffine in 1¼ months.																
Sept., 1904	Stone and clay	14 days	....	14 days	....	1 day	28 days	4 mos.	1	Sound	1	2 mos.	1	Sound	1	2 mos.
Sept., 1904	Marl and clay	14 days	....	14 days	....	1 day	28 days	4 mos.	1	Sound	1	2 mos.	1	Sound	1	2 mos.
Sept., 1904	Slag and stone	14 days	....	14 days	....	1 day	28 days	4 mos.	1	Sound	1	2 mos.	1	Sound	1	2 mos.
SODIUM SILICATE.—Oils dissolved sodium silicate coating in 20 days.																
Dec., 1904	Stone and clay	14 days	7 days	....	....	7 days	21 days	1½ mos.	1	Sound	1	Sound	1	Sound	1	Sound
Dec., 1904	Slag and stone	14 days	7 days	....	....	7 days	21 days	1½ mos.	1	Sound	1	Sound	1	43 days	1	Sound
Regular briquettes to accompany above.																
Dec., 1904	Stone and clay	14 days	7 days	....	....	....	21 days	1½ mos.	1	Sound	1	Sound	1	Sound	1	Sound
Dec., 1904	Slag and stone	14 days	7 days	....	....	....	21 days	1½ mos.	1	Sound	1	Sound	....	43 days	1	25 days
Grand total briquettes, 84.							Total briquettes		21		21		20		21	

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Twenty years ago, when concrete first began to come into extensive use as a building material, there were numerous proposals to apply it for constructing the entire walls of buildings, and many buildings have been actually constructed on this plan. Experience has made clear, however, that this type of construction has serious disadvantages. The first of these is the cost of the molds necessary for the formation of the walls. Even when concrete is laid in large masses, as in lock walls, retaining walls or piers, it is well known that the cost of the wooden forms is a large percentage of the total cost of the work; and in the case of an ordinary building wall, only a foot or so in thickness, the cost of making and placing the molds sometimes outruns the cost of the concrete itself before placing in the wall. The increased cost of lumber within the past few years has further handicapped this method of construction.

Another objection to house walls built of monolithic concrete is the great difficulty of producing a satisfactory surface finish to the concrete. It can be done, certainly, with sufficient care and expense; but inasmuch as a main argument for concrete as a material for building walls is its cheapness, the fact that by spending money enough you can make a good-looking concrete surface does not much help the case for the monolithic construction.

The penetration of moisture is another objection to any solid concrete wall. That this is bound to occur every engineer will concede. Plastering on wooden studding leaving an air space behind, makes a fire-trap construction, and adds again to the bill of expense.

All these considerations tend to restrict the use of monolithic wall construction to foundations. Here surface finish is unimportant, as most of the wall will be covered with earth, and cheap molds can be used, which can be readily braced against the sides of the excavation. The outer surface can be waterproofed, too, with no objections on the score of æsthetic effect.

These defects of the solid concrete wall for buildings have long been apparent, and engineers and inventors have, therefore, turned their attention to the use of a concrete in a different way, by molding blocks of concrete, which are laid up in the wall like cut stone.

For the walls of houses above the foundations there seems every prospect that molded concrete blocks are to be used to an enormous extent in the future.

These blocks can be molded at very small cost. They are of such a size that a wall can be laid up with them much more rapidly than with bricks. The wall produced is of much better appearance than a monolithic wall, and lends itself readily to the use of any sort of architectural decoration; and, the blocks being hollow, furnish an air space in the interior which should add to the warmth and prevent the entrance of moisture.

It is true that some of the structures built with these concrete blocks may be criticized for the monotonous regularity of the surface; but this same objection applies with equal or greater force to much of the architectural work with brick or sawed stone. If architectural decoration of a structure is desired, it can be produced with concrete at a small expense compared with cut stone, and creditable structures can be produced with concrete blocks at a moderate cost compared with other materials.

While concrete blocks are doubtless destined to be used extensively in all parts of the country, they are a development of especial importance to that great section of the Mississippi valley which is far removed from any source of timber supply, and is also lacking in a supply of building stone. Even clay for brick is often unavailable, and where brick can be had it is necessary to build a wooden house inside the brick one to make a comfortable structure. To this great section the successful production of concrete blocks from local materials at a moderate cost is a matter whose economic importance it would be hard to overestimate.

In the Engineering Literature supplement with this issue we have outlined the need of good literature on the subject of concrete block construction, and have set forth a plan which we sincerely trust may stimulate its production. We invite the careful attention of all our readers to our offer of prizes for the best papers on this subject on page 291 of this issue.

The study of fire protection is coming to be well recognized as a legitimate part of the field of engineering. It is sufficiently important in its relations with modern life to demand the services of able and energetic men, and, as it requires constructive and analytical knowledge of a kind peculiar to the engineer, its cultivation and development properly falls within his sphere. This latter remark applies to both branches of fire protection: fire prevention or fireproofing, and fire fighting. But fire fighting, while vastly older than the other (just as the physician antedated the sanitarian by many centuries), has as yet not been so clearly appreciated to be an engineering study as has fire prevention. Indeed, in the sense here referred to, fire prevention may be taken to constitute the whole of fire protection.

In recent times, particularly in the last two decades, much time, money and effort has been given to developing the principles of fire prevention. Foremost among those who have been active in this are the fire insurance interests. Both here and in Europe they have made, and are making, strong and persistent effort, by analytical, statistical and experimental study, to determine the best means of preventing the origin and spread of fire. Their purpose herein has not been abstractly altruistic: their ultimate object at all times was to place the business of fire insurance upon a more stable and economical foundation, by eliminating all but the chance, unavoidable, risk of fire. Rules of construction and equipment have been formulated which will, in the best practicable manner known, afford security against destruction or widespread damage by fire of building structures and their contents. And, as knowledge of relative fire risk accumulated, the suitable adjustment of insurance rates has resulted in discouraging the construction or perpetuation of bad risks; in other words, it has resulted in practical realization of the conclusions reached by the study of fire prevention. Materially lowered insurance rates reflect the general decrease in risk of serious loss by fire.

In a general aspect, fire protection includes more than the protection only of *property*. The safeguarding of life is also part of the subject, and in many applications it is an extremely important part. In most cases, no doubt in the vast majority of cases, the interests of life and property are subject to almost precisely the same conditions as regards fire risk. But in a certain class of cases the safeguarding of life is by no means identical in its means and methods with the mere protection of property. A most impressive illustration of this was given to the world fourteen months ago, in the Iroquois Theater horror. There a fire which lasted less than an hour, and which caused virtually insignificant loss, in damage to the building concerned, wiped out of existence six hundred lives. The building was "fireproof," as are all of our modern large buildings; it merited, and continued to merit, a low rate of insurance. Yet, surely no one will venture to assert, in view of the disaster which actually occurred, that it was the best in construction and arrangement that fire protection engineering could devise. The case is by no means an isolated one, at least potentially. Not to speak of theaters—for since the Iroquois fire the layman is well able to pass opinion on these—we need only mention large department stores, such as they are built in all but exceptional cases. There is in every large city no lack of buildings where large masses of easily inflammable materials are stored together, where people congregate in crowds or assemblages, and where a chance beginning of fire might in a few moments produce a great disaster. All such buildings, as far as concerns structural characteristics, are thoroughly fireproof, but on the broad basis of fire protection, protection of life as well as property, they merit only a very low rating indeed.

It is proper that conditions of this class be kept in mind where questions of public safety are under consideration. Fire protection as a study and an end is as vitally concerned with the protection of life as with the protection of property; fire insurance, on the other hand, is primarily concerned with protection of property, and life is only secondary or incidental. Those responsible for public safety are bound to remember this, and not blindly accept fireproof construction and low insurance rate as a guarantee that the full demands of fire protection are met.

In our issue of March 2 some valuable data were given as to the cost of the concrete work on the south pier at Superior Entry, Wis. When the article was written we did not have an itemized statement as to the cost of the plant for this work, and it was assumed that the cost of pile trestles was probably not included in the allowance made for plant. From data that we have since received from Mr. Clarence Coleman, Assistant U. S. Engineer, who prepared the report on the work, it appears that the cost of trestling was included in the allowance of 84 cts. per cu. yd. for plant—which makes the showing all the more creditable. The following letter from Mr. Coleman shows the exact distribution of the cost of plant over the concrete work:

Replying to your letter of Feb. 25, the plant includes everything accessory to the work trestle, molds, mold traveler and machinery of every description, including all scows with or without machinery, steam tug, etc. As the plant is itemized in my report for 1904, the cost of plant classified may be shown as follows:

Machinery	$30,055.98
Piles and pile driving	13,963.00
Lumber for trestles and molds	12,094.26
Iron and castings	7,572.36
	$63,685.60
Labor on plant	15,760.40
Total cost of plant	$79,446.00

The item for labor on plant includes all work in building trestles, laying track, building molds, mold traveler and on all appurtenances for performing the work.

The contractors in making their proposals for this work were required to contemplate the erection and installation of all of the trestles and accessories, as shown in the drawings which accompany my report for 1904, unless they could show as good or a better plan for accomplishing the work, the officer in charge to be the judge of the efficiency.

The following is a statement showing the basis

upon which the cost of plant per unit of concrete was computed.

Data compiled, assuming that plant and accessories used on construction of South Pier will be used on construction of North Pier:

Original cost of plant and accessories for South Pier		$79,446.00
Probable depreciation and interest of plant through use on South Pier construction, 20%		15,889.00
Value of plant at completion of South Pier		63,557.00
Rehabilitation of plant for North Pier work	$15,889.00	
Estimated increase of original plant when adapted for North Pier work, 5%	3,972.00	
Original cost of plant	79,446.00	
Cost of plant for both North and South Piers		99,307.00
Value of plant at completion of both piers, $99,307.00 — 80% =		19,861.00
Amount of plant chargeable to concrete for both piers		79,446.00
Cost of plant per cu. yd. of concrete for both piers = $79,446.00 ÷ $94,000.00 =		0.84
Cost of plant per cu. yd. of concrete for South Pier, based on the assumption that it is used on that pier only		1.29
Economy per cu. yd. of concrete for plant if used on both piers		0.45
Estimated economy effected by using plant and accessories on the construction of both piers, equal to $94,000 × $0.45 =		$42,309.00

By reference to the article in our issue of March 2, it will be seen that the total cost per cubic yard of concrete was only $4.64, of which the labor cost was only 58 cts. Taking into consideration the fact that the work was done by day labor, with an 8-hour working day, and that the whole work envolved many features of novel design, this very low cost is particularly worthy of record; and furnishes excellent testimony to the executive ability of the engineers who carried out the work. The work was done under the direction of Major Chas. L. Potter, Corps of Engineers, and Mr. Clarence Coleman was in direct charge of construction.

The recent disastrous conflagration at the New Orleans freight and shipping terminal of the Illinois Central Ry. serves to call attention anew to the general use of inflammable construction for the buildings and other structures at large railway terminals. Yet the value of the freight stored and handled at such terminals is enormous, and in addition to the actual destruction of valuable property (both freight and buildings) in case of fire, there is the serious interruption to the business of the road due to the destruction of its terminal facilities. While elaborate equipment for water supply for fire protection is usually installed, the conditions are apt to be unfavorable for the effective use of such protection. It is commonly supposed that fireproof construction is too expensive for use in such structures; but at present prices of lumber and present costs of reinforced concrete construction, the chances are that any additional cost of the latter would be an investment which would soon be repaid in decreased rates of insurance. In support of this we learn that at New Orleans the terminal is to be rebuilt with fireproof structures.

THE FUNCTIONS OF STATE AND NATIONAL GEOLOGIC SURVEYS.

Before a sub-surface survey of the rocks, minerals and waters of a given region is undertaken, a contour survey of the surface should be made. Upon a contour map the geological features are plotted, and, by the aid of the contours, outcrops can often be predicted even where vegetation and surface soils completely hide the rock and minerals. Moreover, a study of the contours is of great assistance in determining the folding and faulting of the strata, especially where erosion has operated to conceal the original configuration.

At the outset it may therefore be said that one of the most important functions of a geologic survey is to make accurate contour maps. Beside the ultimate value of such maps to all who are directly interested in mineral products, there is immediate value to engineers engaged in planning or improving water-works, railways, irrigation works and the like. No mistake, therefore, can be made in a liberal expenditure of available funds in mapping the surface properly.

The next step should be the mapping of the strata, showing dip, strike, outcrops, thickness, petrographical characteristics, etc. Finally, bodies of ore, coal, oil and other valuable minerals or mineral products should be carefully examined, not with an immediate view of developing theories as to their origin, but with the purpose of showing their precise location, quality and extent. In a word, data must be accumulated before any broad generalizations or theories can be safely undertaken. The geologist need not do his work unlivened by speculation, but he should work primarily to collect and present data which others may use.

So logical and so elementary do these statements of the primary functions of a geologic survey appear that even to enumerate them seems unnecessary. Nevertheless, volume after volume of national and state geological reports is issued from the press carrying internal evidence of such a lack of appreciation of the relative value of the work done by official geologists, that it seems necessary to discuss elementary principles, however self-evident they may seem. A great deal of immensely valuable work has been done by the national geological survey in mapping various regions, but we almost lose sight of this valuable work, so lost is it amid the huge piles of reports which either record matter of too little importance to merit publication or which are quite outside the functions of a geological survey. We have before us a volume, reviewed in our last Literature Supplement, strikingly illustrating the degree to which the true functions of a geologic survey may be forgotten by those engaged in it. We refer to Bulletin No. 2 of the Geological Survey of Ohio, entitled "The Uses of Hydraulic Cement." The bulletin is a scrap-book of data on cement and concrete, already published in other books, in current articles, the technical press and in catalogues. Throughout it is written with the apparent object of booming the cement industry, and might very well have been published as advertising literature by any one of the large cement manufacturers. This need not be interpreted to mean that the bulletin is not well written, more or less interesting, and occasionally instructive, for it is. The point we raise is, that it is not the business of a geological survey to publish such matter as this at all. Because an employee of a geological survey writes or compiles a treatise on the uses of cement, or oil or marble or iron, is not sufficient reason why it should be published at public expense any more than if the same man had written a novel or poem. If it is a good treatise, or a good novel or poem, it can be published by private enterprise, and will then achieve far wider publicity than is ever attained by any "pub. doc." If it is a second-rate or third-rate treatise or novel, then by all means let us not take public money to print it, for too many such works already exist.

It is not the business of a geological survey either to boom a manufactured product or to reprint information already published in scientific periodicals and text-books. A geologic survey department may with propriety call attention to the value of certain deposits, or minerals, and it would do well to conduct original investigation to ascertain the physical or chemical properties of certain minerals, with a view to indicating their prospective commercial value. Portland cement, however, needs the aid of no geological survey bulletin to make its value known.

As another illustration of the point we wish to make: the Wisconsin Geological Survey issued about a year ago a report containing valuable information concerning the materials available for road-building in the state. Its compiler, however, was not content with this, but attempted to make the document a sort of popular text-book on road-building. We called attention at the time to a few of the numerous errors in the road-building part of the report, arising from the fact that its author was a geologist and not a civil engineer. But even had there been no such errors, and had the report been the most perfect text-book on road work ever published, we still maintain that the publication of such a text-book is no part of the function of a geological survey.

We do not raise this protest by any means on behalf of the publishers of scientific books. Notwithstanding the tons of scientific literature which are poured forth week after week by the Government printing office, we have yet to learn of any case where the sale of any treatise published by private enterprise has fallen off because of the distribution gratis of public documents on the same subject. Our protest is on behalf of engineers, miners and manufacturers, who regret to see a single dollar of the appropriations made for the proper work of the Geological Survey turned into other channels.

So long as vast areas of this country remain unmapped, and practically unexplored, let us have more surveys, and fewer verbose and ponderous reports as the product of our geological survey departments.

LETTERS TO THE EDITOR.

Computing Deck Plate Girder Bridges.

Sir: The "Short Method for Computing Deck Plate Girder Railway Bridges," described by Mr. Paul Alexander Blackwell, Jun. Am. Soc. C. E., in your issue of March 2, will be found in Humber's Handbook, "Strains in Girders," where, so far as I know, this particular method of drawing a parabola was first described.

Yours truly, M. J. Butler.

Ottawa, Ont., March 4, 1905.

Concerning Methods of Calculating Cross-Section Areas

Sir: In addition to those already noted in your columns as having used the method of calculating cross-section areas, described by Mr. V. A. Kauffman (Eng. News, Dec. 22, 1904), let me add that this method has been used in this district (Third District Mississippi River Improvement) in calculating cross-section areas of levees and levee enlargements for the past 18 or 20 years. We use the scheme exemplified by Mr. John S. Worley in Engineering News of Jan. 19. It was introduced by the late Henry Goodrich, who was then one of the U. S. Assistant Engineers in this district. It is known here as the "sectionoid method," "but I could never tell why."

This method can be applied very conveniently in getting the content of a cut, or an embankment, without averaging the areas—even where many +'s are used—by treating the areas (or the corresponding yardage) as fills, and the stations and +'s as distances out.

Very respectfully, John J. Hoopes.

United States Engineer Office

Greenville, Miss., Feb. 26, 1905.

Ventilating Sewers Through House Soil Pipes.

Sir: With reference to the recommendation of Mr. Allen Hazen to ventilate the sewers through the house soil pipes, at Winnipeg, the writer can bear testimony from ten years' experience that probably no better method could be devised. The idea is to connect each soil pipe in a building, and other drain pipes where necessary, with a vent pipe passing through the roof, and then provide at some suitable and convenient point an air induction opening into the sewer or sewer connection, also omitting the house trap. The result will be a very satisfactory circulation, from the induction opening through the sewer branch, up through the soil and drain pipes, and out of the vent pipe at the roof; all of the house connections within the building being properly trapped, where necessary, into the soil and drain pipes, these pipes being vertical and free of obstruction from bottom to top. It may be difficult to adapt such a method to some buildings already in existence and where badly designed drainage has been installed, without considerable expense, but in new buildings there is no reason why cleanly, free, and perfectly ventilated sewer service cannot be obtained. The sewer lines in the streets could thus be completely ventilated, and it would not be possible in the absence of some sort of gross negligence or abuse for gases or contaminated air to enter the houses.

Chas. A. Hague.

114 Liberty St., New York City, March 9, 1905.

Use of the 2,000 lb. Ton in the United States.

Sir: In yours of Feb. 23 (page 203) you say that the word "ton" in the U. S. means 2,000 lbs., except in a few isolated cases, where the old "gross ton" is used. Evidently times have changed considerably since Mr. Trautwine noted in the preface to his Pocket Book that the word, as there used, always meant 2,240 lbs., "because that is its meaning in U. S. Law." Can you tell us something more about the "isolated cases" you mention, and whether the law has been changed or not?

Yours, T. P. Perkins.

Engineering Dept., Boston & Maine R. R.

Boston, Mass., March 7, 1905.

(When the elder Trautwine wrote the preface

to his "Pocket-book," the gross ton was in far more general use than it is to-day. So far as we are aware, no statutes have been altered; but the greater convenience of the 2,000-lb. ton in all computations has tended to bring it into use and to displace its older rival. Iron ore, pig iron, and steel rails are bought and sold as gross tons, and hard coal is dealt in by the same generous measure until the final consumer who buys at retail is reached. Soft coal, throughout the middle West, is sold by the short ton, crushed stone is seldom sold by the long ton; and ores carrying the precious metals, copper, lead, etc., are all weighed in tons of 2,000 lbs. In maritime matters, we believe the gross ton still persists as evidence that Great Britain has taught the whole world the art of shipbuilding and the business of sea transportation. Elsewhere, so far as we now recall, the 2,000-lb. ton is the one commonly used.—Ed.)

A Corrected Account of the Explosion at Shaft No. 1, of the United States Coal & Coke Co.

Sir: I noticed in the Engineering News, March 2, 1905, which has just reached me, an account of the explosion in the shaft at No. 1 Works of the United States Coal & Coke Company. I presume, of course, this notice was taken from the press notices of this explosion, and I wish you to make a correction in your columns. Any accident of this kind is deplorable enough without its being as grossly exaggerated as this one was. The explosion occurred about noon on Sunday, Feb. 26, in the lower, or No. 3, seam of the shaft. There were seven men, instead of twenty-three, in the mine at the time, who were engaged in laying a switch near the shaft bottom, which could not be put in during the week. All of these men were killed. The mine was inspected by two of the State Mine Inspectors on Mar. 1, and their report states that in their opinion the explosion was caused through the carelessness of the employees in taking a large quantity of powder or dynamite into the mine. The damage to the mine was very slight. You will remember a description of the concrete shaft at this mine was published by you some months ago, and will be interested to know that, although the greatest force of the explosion was manifested at the foot of the hoisting shaft, no damage was done at all to the concrete work.

This mine was opened last year, and no expense has been spared in its equipment or operation to make it and keep it as safe as possible. None of the workings are as yet more than about 900 ft. from the foot of the shaft. The mine is ventilated by a Capell fan 20 ft. in diameter and 7 ft. wide. Yours truly,

Howard N. Eavenson,
Chief Engineer, United States Coal & Coke Co.

Gary, W. Va., Mar. 7, 1905.

Sulphur in Blast Furnace Slag Used for Ballast.

Sir: In your issue of Feb. 16 you inquire for experience with blast furnace slag used as ballast, with reference to its use in ballasting bridges with solid steel floors.

The Philadelphia & Reading Ry. has in the past used a very considerable quantity of such slag for ballast, and during the term of my employment by that road they had it in use from Jenkintown to Bethlehem, on portions of the Germantown and Norristown branches, and had in the early '90's used it entirely between Reading and Harrisburg. Our experience with it was that it made a very elastic roadbed, and while it was not entirely satisfactory under a very severe traffic, owing to its grinding to a dust under such conditions, it was, in my belief the most satisfactory ballast that could be used on track where the train service was not too severe. It must be borne in mind that there are different qualities of slag, and we were fortunate in having a slag which had been made by the old-time furnaces. The older slag is much harder, more dense and freer from soluble acids. For instance, some years ago we had a lot of slag from the Bethlehem Steel Works. This was so porous and light that the soluble acids from it caused our ties to be eaten up within two years, against a previous life in excess of five years. On a warm day the sulphur odor was so pronounced that none of us cared to walk over that section of track. A few years ago while using old style slag for concrete I had occasion to break it to smaller sizes, and found that the sulphur showed in the lumps in streaks, while the slag was so dense that it was very unlikely that it would ever be dissolved. There is no reason why slag should not be freely used for either ballast or concrete, but care should be taken to select the harder and more dense kind, and old style furnace slag be used if it can be obtained.

Yours truly, F. D. Hain.

Pleasantville, N. J., March 4, 1905.

A Log Mat for Covering Blasts.

Sir: In your issue of Feb. 23, Messrs. Yanger and Bettefeld, Indianapolis, Ind., want information regarding a chain "blanket" for stone blasting, to keep stone from flying.

The writer has never used a chain blanket manufactured for this purpose, but has used chains as "binders" for blankets made of logs and other such material, and has found that when the chains happened to receive the impulse of the explosion direct they parted, sometimes into several pieces. These chains were composed of ¾ and ⅞-in. links.

The most generally satisfactory covering for a blast, outside of special conditions, can be laid on in the following way: Take steel wire rope (some that has seen service will do, provided it is not too badly worn), cut off at least three pieces of sufficient length to wrap round a layer of logs of green, straight, hard wood. First lay down the ropes in such position that the first rope will be at least 18 ins. from ends of logs and towards the middle of same. The second rope placed so it will enwrap the middle of the logs; and the third rope should be placed to correspond with the first. Then lay on the logs at right angles to ropes and as close together as they will lie. Having thus covered the surface likely to be violently disturbed by the shot, bring the respective ends of each rope separately together (have rope long enough so that the ends will overlap), pull tight so all possible slack is taken up and fasten with common rope clamps. Treat each rope in this way. Then take a strand of same kind of rope and with it tie upper and lower parts of same rope—tie up and down between logs—at as many points as may be judged necessary to make secure. If the conditions call for extra weight, the same can now be added by placing pieces of stone, not less than 100 lbs. each, near and inside the first and third ties.

The above is only intended for general cases, but where unusual conditions prevail nothing but experience will add to the necessary precautions.

Yours truly, Edward Burns,
Supt. Lake Shore Stone Co.

Belgium, Wis., Feb. 25, 1905.

Notes Regarding Sewage Disposal at Paris and Berlin.

Sir: I have recently received the annual reports of the operation of the sewers and sewage disposal systems of the cities of Paris and Berlin for the year 1903. A comparison of the conditions of these two cities is particularly interesting, as they are by far the largest cities in the world purifying their sewage by broad irrigation.

Paris was the pioneer in this matter and for many years treated a portion of its sewage. Berlin took the matter up later, but carried it forward with more vigor, and for many years has purified all of its sewage except a small amount of storm overflow. More recently Paris has completed its system, and for some years no untreated sewage has ordinarily been discharged into the Seine.

It is interesting to note that in Paris the greater part of the irrigated land is under private ownership but takes sewage by agreement, and in general in such quantities as are required by the crops. At Berlin, on the other hand, the whole irrigated area is owned by the city.

Corresponding figures for the two cities are as follows:

	Paris.	Berlin.
Population by last census	2,714,068	1,956,040
Drinking water supply, gallons per capita daily	32	21
Unfiltered river water (not used for domestic purposes)	62	.....
Total water supply, gallons per capita daily	94	21
Sewage pumped, gallons per capita daily	50	32
Area actually under irrigation, in acres	13,100	17,500
Average quantity of sewage applied, gallons per acre daily	12,300	3,530
Number of persons per acre	207	112

The excess in the quantity of sewage over the water supply at Berlin is in part due to the very extensive use of water from private wells for manufacturing purposes, and in part to rainwater entering the sewers. The sewers are on the combined system, and in time of heavy rains there are some overflows of untreated sewage.

At Paris apparently a great deal of the unfiltered river water, which is used for washing streets and for public purposes, must find its way back to the river without going through the sewers, for the amount of sewage pumped is far below the volume of the water supply.

It is interesting to note that at Paris, of the whole volume of sewage applied to the land, fully one-half reappears in the drains, where it is measured, and samples showing the degree of purification are regularly taken. The analyses are made at the municipal observatory at Montsouris, and "continue to demonstrate the perfect harmlessness of the waters after their passage through the soil."

At Paris the cost of pumping and distributing the sewage, not including interest and sinking fund charges, is $11.30 per million gallons. At Berlin the cost of pumping is about $9 per million gallons, and the income from the farms somewhat exceeds the cost of operating them.

Allen Hazen.

220 Broadway, N. Y. City, March 10, 1905.

(In this connection we note a recent report of U. S. Consul-General Frank H. Mason, dated Jan. 18, 1905, just issued by the State Department, in which it is stated that in 1904 the Berlin sewage farms paid for the first time a net profit above the cost of operation and maintenance. This is an error. We have before us the official report giving financial statistics of the Berlin sewage farms for a series of years. It there appears that in 1903 the farms yielded a profit of 381,866 marks, and profits have been made in every year since 1885 with the exception of the years 1892, '93 and '94 and 1900 and 1901.—Ed.)

Validity of the Patent on the Wakefield Sheet Piling.

Sir: Suit in a considerable amount has been brought against the Sewerage and Water Board for royalty for the use of Wakefield sheet piling, used mostly on drainage construction before the undersigned was connected with the work, between the years 1897 and 1902. I would esteem it a favor if you or any of your readers would inform me, 1st, what, if any, evidence there may be of the use of such sheet piling prior to September, 1887 (date of patent); secondly, whether subsequent to that date payment of royalty under said patent has been enforced by any court.

In the issue of Engineering News of October 6, 1892, Mr. O. M. Weand, Engineer and Contractor, writing from Reading, Pa., seems to say that he has known of the use of this form of sheeting for 20 years.

Any information in this connection will be sincerely appreciated. Respectfully,

Geo. G. Earl, M. Am. Soc. C. E.
602 Carondelet St., New Orleans, La., March 2, 1905.

(Proof of the above letter was submitted to the Wakefield Sheet Piling Co., with an invitation to present a reply for publication, if so disposed. The letter received in response follows.—Ed.)

Sir: Accept our thanks for the copy of the letter of inquiry of Mr. Geo. G. Earl, M. Am. Soc. C. E., which you purpose to publish in the Engineering News next week.

After having received royalties amounting into the thousands of dollars from nearly if not every state in the Union, and after the expiration of our patent, there seems to be little object in our fighting out the merits of the expired Wakefield patent in the press when the court has it in hand. For the benefit of your correspondent, however, we will say that we have been forced to appeal to the courts in a large number of cases to secure our rights, and that priority of use was relied on in most of such cases. Usually such cases have been too visionary and obscure for the definite following of such down. One case, however, which was sworn to by the contractor who did the driving and who exhibited a perfect model of our device as having been used by him in or about 1882 and also sworn to as correct by one of the brightest professors of a celebrated school, and corroborated by other eminent civil engineers who all identified the sheeting, the time, the place and the photograph thereof, we carefully followed to conclusion.

The defence having made positive proof, closed the case. We then obtained permission to remove one of the piles that entered into the sworn line, and still have it for exhibition. If the three planks that composed that pile were bolted or fastened as stated into the form of triple-lap sheet piling, then the spikes used must have been skillfully driven into place head foremost. In other words, the gentlemen were simply mistaken, and that, like the other cases, was decided in this company's favor and the penalty for use without permission duly paid.

Respectfully,
Thos. M. Nelson, Secretary.

Rookery Building, Chicago, March 10, 1905.

(There is also enclosed a printed copy of a decision by Judge Showalter of the United States Circuit Court of the Northern District of Illinois, Northern Division, ordering an injunction and accounting in Case No. 794. In Equity, Wakefield Sheet Piling Co. vs. Hiero B. Herr and R. S. Walsh, dated April 9, 1898.

We shall be pleased to hear from any of our readers who can furnish any further definite information on this matter.—Ed.)

Health Precautions for Engineers in the Tropics.

Sir: I read with interest the article on "The Equipment of Engineers Going to Panama," which appeared in the current issue of Engineering News. The method of the conservation of the health of Americans going to the Isthmus, who will be subjected—in many cases—to a complete change of climate and diet, should, indeed, be very carefully considered by prospective inhabitants of the Canal Zone.

To aid in this, if possible, I beg to supplement the above-mentioned article by referring the readers of the News to Chapter XL. of Wilson's "Topographical Surveying," and by a few notes, taken for the benefit of those not possessing this work, from that chapter, with some of my own. These notes, clearly, will apply especially to men out on the canal line: those out of reach of the medical corps in the cities.

The more intense the heat of the sun's rays and the more penetrating, as in the tropics, the heavier should be the head covering. Under such circumstances a

heavy pith helmet may be used; but whether helmet or heavy felt sombrero be worn, a band made of light linen or India silk, folded to about 3 ins. in width and of a length of about 2 yds., should be wrapped around the hat close to the brim, so as to make a thick pad over the temples to keep out the penetrating rays of a tropical sun.

For sleeping clothes, pajamas only should be used, and in the tropics especially these should be of light flannel. Also in the tropics flannel cholera bands should be invariably worn over the abdomen and *never* removed except to change.

I think that cleanliness will be of the greatest aid in preserving the health of the Americans in the Canal Zone, and every opportunity should be seized for bathing, to keep the skin in a healthy condition. Soap, towels, etc., should not be omitted from the outfit. Toilet paper is very essential to prevent piles.

While in the Bad Lands, in midsummer last year, I contracted mountain fever, through carelessness. The disease was brought on by sudden changes of the temperature of the body, and by drinking sulphuretted and alkaline waters when very thirsty. Dysentery and malarial fevers ensue from such a practice, and the importance of having pure drinking water in all climates cannot be overstated. All energy should be put forth to obtain pure water, besides refusing to drink bad water to the limit of endurance; better not at all. If one becomes thirsty and is without drinkable water, a small clean pebble placed under the tongue will collect saliva and prolong the endurance against thirst.

If sleeping out in the night air, a knitted cap should be worn to protect the head from the dew.

Heavy foods and flesh foods should be used sparingly. Fresh meats once a day in moderate quantities should be eaten to keep up the system, but not more than one such meal a day should be consumed. . . . Eggs should not be indulged in too freely. Cereals, as rice, cornmeal and good bread, beans and peas should be used freely. Fresh fruit should be used most carefully and sparingly.

The chapter referred to gives some valuable "Medical Hints," some notes on "Serpent and Insect Bites," some "Surgical Advice," and notes on a "Medical Chest."

To the chest of drugs, recommended by Mr. Harris in the article above referred to, there might be added: Carbolic acid, "to prevent attacks from insects and to destroy ticks"; surgeons' adhesive plaster, paregoric, sedative, mustard, in tin; several long bandages, absorbent cotton, collodion, etc., although the danger of overloading one's outfit should be guarded against if much transportation is to be expected. Very truly yours,

Alexander S. Ackerman.

Newport, R. I., March 5, 1905.

More Concerning Specifications for Sand.

Sir: Referring to your editorial, "Concerning Specifications for Sand," appearing in your issue of Feb. 2, 1905, it appears to the writer that your condemnation of a clean, sharp sand and endorsement of an unclean sand is rather too unqualified. The action of the Chicago, Milwaukee & St. Paul Ry. in using various sands carrying percentages of clay was, of course, entirely proper because tests showed such sands to give required results. In all similar cases where sand can be tested beforehand and then used by the party, as a railway company, direct, without the intervention of a second party, the contractor, a sand should be used or rejected solely on the basis of its ability to give required results in mortar. Also if the party proposing to have certain work done could determine in advance that a certain adulterated bed of sand was available and suitable, such sand could be specified safely for use in the work to be done and, if the most economical, should be used.

However, much the greater part of the construction work of the country is done by contract and a specification admitting an adulterated sand would surely open a fertile field for controversy between the contractor and the engineer. There would certainly be differences of opinion as to the percentage of adulteration actually in the sand. With a specification calling for clean sand, contractors will bring an unclean article and strenuously contend that it is quite clean and fully satisfies the specifications. They will be much more prone to bring 20% of clay with the sand if the specification admits 10%. Short time tests on the work to determine the quality of a sand are not practicable or reliable. There is always danger in using a dirty sand unless conclusive tests have previously proved that the particular article in question is safe. On the other hand, the time-honored requirement of cleanliness is always safe and its insertion in specifications for general contract work equally so, consequently, it is not ignorance nor prejudice that retains it.

Where it is desirable and proper to use an adulterated sand it will be better to say in the specifications that the sand shall be subject to the approval and acceptance of the engineer rather than specify a percentage of adulteration, or, much better still, that the sand shall come from certain deposits or beds if the necessary information is available when the specifications are written.

In the second place, the writer cannot agree with you, in the light of his personal experience, that salt water is not injurious to cement mortar. It may or may not be materially detrimental, depending on the degree of saltness. Moreover, he would say that the use of salt to prevent freezing is based on ignorance rather than the requirement of clean sand. Weather cold enough to damage concrete or mortar materially will freeze the strongest brine, and the use of salt is worse than useless.

Yours truly, J. L. Campbell.

El Paso, Tex., March 2, 1905.

(We did not intend, in the article referred to, to condemn the use of clean sand by any means, or to advocate the use of dirty sand in preference. What we did wish to urge is that in localities where the use of clean sand means a considerable addition to the cost of the work, engineers should not hesitate to use local sands, which would a few years ago have been condemned as wholly unfit for concrete, but which, from the information recently made public, we now know to be probably as good as sand brought from a long distance. A specification is written that the contractor may know beforehand what will be expected of him, so that he may fix his bidding price accordingly. If the specification calls for "clean, sharp sand," in the time-honored fashion, how shall the bidders know that the engineer will permit the use of any other? The suggestion that where it is desired to save expense by the use of such local sands, the specification should name the particular deposit or deposits from which the sand may be taken, appears to us an excellent one.—Ed.)

Field Book Methods in Railway Surveys.

Sir: Believing it very unfortunate that so many practicing engineers and more students are slaves to the use of hand, field or other technical books in the matter of the solution of special problems, I beg to cite the case of the "Problem in Railway Location" which appeared in your issue of Feb. 23, p. 206. The writer of the letter in question presents, on the whole, an excellent solution of the problem of finding a tangent to a curve from a fixed point and certainly deserves the thanks of those in the above category, i. e., slaves to hand-books.

But many of the larger class, who habitually use their heads and knowledge of elementary mathematics in preference to some one else's cut and dried solutions, will wonder why so simple a matter was thought worthy of so much time and space. In fact, this identical thought, coming from one of my students, led me to investigate the matter and write this letter as a result.

I found that nearly all field books gave only the restricted solution mentioned by Mr. Stowell as found in Shunk's "Field Engineer," and none, so far as I have been able to find, recognize the more general case shown in Fig. 1 of last week's letter, though it is just as capable of solution by plane trigonometry as the problem of finding a tangent distance or a long chord.

Mr. Stowell, however, misinterprets the use of the trial secant line, FJB, as this line of course becomes unnecessary when *any surveyed or known connection whatever* already exists between the curve and the fixed point, as in his first problem. This, in my opinion, was why Mr. Shunk's method was inapplicable, not because it would have required the survey of a line 3,000 ft. long through bad country, as stated by Mr. Stowell.

The only other point on which I fail to agree with Mr. Stowell is in limiting the trial line, either in survey or later by calculation, to only two courses, i. e., the finding of the point H is not necessary. If he will use OB and a perpendicular to it through O as axes and project all his courses on these, finding in that way the coordinates of the point F and then OF itself, I think he will agree with me that the solution is simple for *any number* of courses and preferable to the method of using the oblique triangles involved.

Otherwise the solution is an excellent one and I now return to my main purpose of discussing the defects and, I believe, too extended use of field books.

The specific defect shown above is no doubt a real one, though small. Yet who can say how many miles of unnecessary "trial line" have been run, due to a blind, unreasoning following of this method. If Mr. Shunk, and others, had connected the fixed point with the center of the curve as Mr. Stowell did, then probably he and possibly the *others* also would have given us the simpler solution not involving the measurement of the unnecessary chord, JB. It is fair to say that one book does mention this possibility.

Some will say that it is an impossibility to cover all cases in a book of reasonable size and I will agree with them, feeling thankful that it is so, as well as sorry, that so many have been covered. For, even with our present field books only, it is possible to find almost any problem or a similar one and hence we have the condition of affairs first mentioned. If all cases could be covered we would have even more "mechanical" solutions and less thought.

I will admit also, of course, that cut and dried solutions and formulas are often great time savers but believe that such finished formulas cannot be intelligently applied by those incapable of deriving them, or at least thoroughly understanding their derivation. Furthermore, I doubt any saving of time in cases similar to the above and fail to see why problems involving the railroad "circle" and its tangents should be considered harder than those involving other circles and their tangents.

But, if the authors of field books themselves show so little originality and so great a tendency to follow each other, can we expect our students to wean themselves from the "handbook habit" and to use their own heads instead? Respectfully,

Fred. Asa Barnes, M. C. E.,
Assoc. M. Am. Soc. C. E.

Ithaca, N. Y., Feb. 28, 1905.

Ritter's Formula for Reinforced Concrete Beams.

Sir: Mr. Hawkesworth in your issue of Feb. 9, 1905, repeats his misconception of Prof. Ritter's formula. Speaking algebraically, his equations contain no error, and in that respect are mathematically interesting, but since they are based on a false foundation, viz., a misconception of the term "equivalent area," his final results, as he endeavors to use them, are of absolutely no value.

When engineers use the word "equivalent area" in the theory of flexure, they mean that they can replace a certain area of one material, say steel, by another area, which will, so far as flexure is concerned, act precisely as the material, say concrete, lying on the other side of the neutral axis. This imaginary cross-section of the beam may then be treated as one homogeneous mass, and the neutral axis may be found by determining the position of the center of gravity of the section; for in a homogeneous material the neutral axis passes through the center of gravity of the section.

Let it be desired to change a steel section in a reinforced concrete beam to an equivalent area of concrete. Let c and f represent the intensities of stress of the concrete and steel respectively from the neutral axis, and let E_c and E_f represent the corresponding co-efficients of elasticity of these materials. The strain in any infinitesimal cross-section of steel, distant m from one side of the neutral axis, is precisely the same as that of an equal infinitesimal area of concrete, distant m from the other side of the neutral axis. That is:

$$\frac{m - c}{E_c} = \frac{m - f}{E_f} \qquad \text{or}$$

$$f = \frac{E_f}{E_c} . c .$$

That is, the area of steel is precisely equivalent to an area of concrete multiplied by the ratio $\frac{E_f}{E_c}$.

This statement has been found, in the preceding analysis in a general way for any infinitesimal area of steel at any distance from the neutral axis; it therefore applies absolutely to the entire section of steel. This area is Ritter's equivalent area, and is that used by concrete engineers. This area must not, in addition, be multiplied by a ratio $\frac{y}{u}$, as Mr. Hawkesworth believes.

It is true that Mr. Hawkesworth does obtain some area which is equal to another area, but he can make no use of it by obtaining the center of gravity of the section, for determining the position of the neutral axis. If he were, however, to combine his equation with $y + u =$ depth of beam, he would obtain an equation determining the position of the neutral axis. "Engineer."

Feb. 20, 1905.

Sir: In reading the criticism of my deductions concerning Prof. Ritter's formula, the most remarkable statement appears to be the one that, starting with admittedly correct assumptions in regard to stress and strain in a beam, and working out an equation which is mathematically correct, this equation nevertheless expresses an untruth. As an equation is only a statement of fact expressed in mathematical language, it seems paradoxical that the equation can be correct, but not the fact which it expresses.

Referring to "Engineer's" letter, I would certainly like to know what is meant by the assumption, "let c and f represent the intensities of stress of the concrete and steel respectively from the neutral axis." I cannot believe your correspondent meant to write anything so meaningless as this would indicate.

It is perfectly true that the strain per unit of length, in the concrete, at any fixed distance m from the neutral axis, is equal to the strain per unit of length in the metal, at the same distance m on the other side of the neutral axis. Therefore, if the unit stress in the concrete distant m from the neutral axis is c, and the unit stress in the metal at a distance m on the other side is f, then the equation given by "Engineer" is perfectly correct, viz.:

$$\frac{c}{E_c} = \frac{f}{E_f}$$

$$\text{and hence } f = \frac{E_f}{E_c} c$$

Exception must, however, be taken to the statement

that this is a general equation. It is a statement of fact only when the strains at equal distances m on either side of the neutral axis are considered. To introduce a limiting condition such as this, and then claim that a general equation has been reached, is about as evident a mistake as could be made.

If c represents the unit stress in the concrete at any distance u above the neutral axis, the unit strain at this point is $\frac{c}{E_c}$. Similarly if f represents the unit stress in the metal at any distance y below the neutral axis, the unit strain in the metal at this point is $\frac{f}{E_f}$.

These strains are evidently not equal except for the special case taken by "Engineer," where u and y are equal to each other, that is, each is equal to m. When u and y are unequal, as is generally the case in a reinforced concrete beam, where we are forced to consider our values of c and f at points of maximum stress in concrete and steel respectively, the strains at these points, distant respectively u and y from the neutral axis, are to each other as u is to y. This comes from the common theory of flexure and gives us at once the general equation

$$\frac{c}{E_c} : \frac{f}{E_f} = u : y$$

$$\text{from which } f = \frac{y}{u} \frac{E_f}{E_c} c$$

For the special case mentioned above, where y equals u, this equation reduces to the one given by "Engineer."

Respectfully yours, John Hawkesworth.

100 West 80th St., New York City, March 2, 1905.

Sir: I have been reading with interest the discussion of Professor Ritter's formula by Mr. John Hawkesworth and the "Engineer" in the columns of the Engineering News. I hoped to see further comments by the "Engineer." I felt that he was the one entitled to reply to Mr. Hawkesworth. His silence gives me a chance to make a few remarks.

The "Engineer" was hasty in saying that Mr. Hawkesworth based his work on poor foundation, because he labelled his quantities in a certain manner. There is no harm in that, provided, one adheres to the labelling throughout the discussion. Mr. Hawkesworth was more than hasty in his statement, at the end of his discussion, of Jan. 12, "The fact that these formulas of Prof. Ritter's, having such a striking error in their deduction, are used by a large number of so-called "concrete engineers, etc." So striking an error could not escape the notice of so many able engineers, and Mr. Hawkesworth's statement challenges their intelligence.

I will confine myself solely to Mr. Hawkesworth's equation

$$\frac{c}{E_c} : \frac{f}{E_f} = AA' : cc' \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and put down the definitions of these quantities as Mr. Hawkesworth has them:

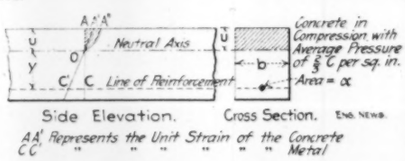
c = maximum intensity of compressive stress in the concrete. It is represented by A A'' in the sketch.

f = maximum intensity of tensile stress in the metal. The area of reinforcement is assumed to be so small with reference to the total area of cross-section of the beam that the stress in the metal is practically uniform.

A A' = the unit strain in the concrete under stress c.

c' c = the unit strain in the metal under stress f.

The quantities AA' and c'c represent unit strains in the concrete and metal under stress c and f respectively, but Mr. Hawkesworth fails to state at what distance from the neutral axis, whether at a unit's distance or in the extreme fibers. If he means at a unit's distance, which I think he does not, then "Engineer" is right and Prof. Ritter's formula is correct, as far as Mr. Hawkesworth is concerned. But on the examination of Mr. Hawkesworth's formula and from the definitions we may, and, indeed, must, infer that he meant the strains in the extreme fibers.



AA' Represents the Unit Strain of the Concrete
CC " " " " " " Metal

Referring to Mr. Hawkesworth's diagram, particularly that part of it representing strains, the following may be inferred: namely, "that the strain in a unit fiber of the concrete at a unit's distance from the neutral axis under the stress "c" equals the strain in a unit fiber of the metal at a unit's distance from the neutral axis under the stress "f."

This can not be so on the face of it, for two different substances subjected to two stresses differing in amount, all else being the same, must be strained unequal amounts and when the two substances are not the same another element of difference must be taken care of. It thus becomes plain that the two triangles AOA' and COC', in Mr. Hawkesworth diagram, are not similar and therefore the proportion in equation (1) is not valid and Professor Ritter is not down. I may be wrong, if so, I should be very pleased if Mr. Hawkesworth or some one else in the profession, who takes an interest in young engineers, would set me right.

In conclusion, I wish to say that discussions ought to be frank in their nature, restricted solely to facts and not have in them the personal element, which was displayed by the "Engineer" and particularly by Mr. Hawkesworth.

Respectfully, Alexander S. Solow.

Union Station, Albany, N. Y., Feb. 23, 1905.

Notes and Queries.

J. L. D., New York City, asks for formulas for computation of flow in wood and cement lined pipe of sizes 2 to 10 ins. For example, values of c in the well known formula $v = c\sqrt{rs}$, or other formulas which have been found useful. Also notes would be welcome as to experience with pipes of these materials regarding strength, durability, tightness of joints, ease of making connections, etc.

"A California Engineer's Wife" writes:

To correct your assertion and to benefit those to whom a wrong impression may have been given by your reply to "Engineer's Wife" on p. 205 of the issue of Feb. 23, I enclose page 38 of the "Woman's Home Companion" for February, 1905, on which page nearly two columns are devoted to the latest fashions for *men*.

(The two columns enclosed are headed "For the Well-Dressed Man," and are written by "Grace Margaret Gould." Doubtless "California Engineer's Wife" thinks that this fills our specification of "a man's column"; but we are obliged to dissent. Our belief is that such an article will interest the average man's wife much more than it will the average man. It is she who tells him if his collar is too low and his necktie the wrong shade; and how shall she know what are the latest fashions in men's apparel except the "Woman's Home Companion" tells her? Of course we give that journal and Grace Margaret Gould credit for good intentions. She says (and doubtless believes) that "men are very much interested in fashions for themselves"; but in the next sentence she records her experience with the sex as follows: "Obstinacy seems to be second nature to many men, and quite frequently a man wears only what he wants to." If that sentence does not reveal the attitude of the author as an instructor of wives in the art of teaching [obstinate] husbands how they ought to dress, then we know nothing about the Higher Criticism.—Ed.)

S. C. C., Norristown, Pa., writes: Will you kindly tell me how the geographical center of population is determined for a city, state or country?

As an answer to the above query we reprint the following description of the method used in finding the center of population from the "Report of the Twelfth Census of the United States, Vol. I., p. XXXV.:

The center of population is the center of gravity of the population of the country, each individual being assumed to have the same weight. In order that the result might be comparable with those obtained in 1880 and 1890, the population of Alaska and Hawaii, although included in the Twelfth Census, has not been considered. The method used was in brief as follows:

The population of the country was first distributed by "square degrees," as the area included between consecutive parallels and meridians has been designated. A point was then assumed, tentatively, as the center, and corrections in latitude and longitude to this tentative position were computed. In this case the center was assumed to be at the intersection of the parallel of 39° north with the meridian of 86° west of Greenwich. The population of each square degree was assumed to be located at the center of that square degree, except in cases where it was manifest that this assumption would be untrue, as, for instance, where a part of the square degree was occupied by the sea or other large body of water, or where it contained a city of considerable magnitude which was situated "off center." In these cases the position of the center of the population of the square degree was estimated as nearly as possible. The shortest distances between each such center of population of a square degree (whether assumed to be at, or at a distance from, the center of the square degree) and the assumed parallel and meridian were obtained. The population of each square degree was then multiplied by the shortest distance of its center of population from the assumed parallel of latitude, and the sums of the products, or moments, north and south of that parallel were obtained. Their difference, divided by the total population of the country, gave a correction to the latitude of the assumed center of population. In a similar manner the east and west moments were obtained, and from them a correction to the longitude of the assumed center was obtained.

MASONIC TEMPLE OF REINFORCED CONCRETE CONSTRUCTION AT TOLEDO, O.

The new Masonic Temple at Toledo, O., is an interesting example of reinforced concrete construction for buildings of a class which are rarely built with much regard to fireproof considerations. This building is 100 × 110 ft. in plan, and 80 ft. high, and was originally designed to be of timber construction inside, with wooden columns and joists 2 × 14 ins., 16 ins. apart. The number of fires in buildings of this class last year, however, caused the Building Committee, upon the urgent advice of the architect, to investigate the merits of reinforced concrete construction. A design was submitted by Mr. L. J. Mensch, of Chicago, and A. Bentley & Sons, of Toledo, whereby all the columns, floors, principal partitions and stairways could be made of fireproof construction at an additional cost of about 6% of the estimated cost of the building, which was $100,000. This design was adopted.

The soil being of very uncertain nature it was decided not to allow a load of more than 3,500 lbs. per sq. ft. on the ground; all live loads were disregarded, as they are very light and very changeable in this class of work. It was decided to build the outside wall of the sub-basement of concrete, with a footing having an average width of 8 ft. The wall with its footing forms a continuous girder, strong enough to distribute the loads over a great length in case any one part of the ground should be deficient in sustaining capacity.

The two sections, Figs. 1 and 2, show clearly the general structural design of the building, together with the arrangement and dimensions of the concrete girders and floors. It also shows the concrete basement wall, above referred to, which is continuous around the entire area, except at one point where it is pierced by an arch. Interior columns rest upon individual footings, and the brick partition walls between these columns are toothed to bond with the concrete. The outer walls are of brick, faced with stone, and enclosing columns of reinforced concrete.

The building has a sub-basement for storage purposes, and a basement for club-rooms and bowling alleys, etc. On the first floor are two large halls, about 47 ft. wide and two stories high; one is called the Assembly Hall (47 × 80 ft. in the clear) and the other the Blue Lodge Room (47 × 52 ft.). Part of the second floor consists of a small banquet hall, 25 × 50 ft., and the parlors, while in the rear is the kitchen. On the third floor is the Commandery Hall, which is about 34 ft. high, with a stage in the rear, and has a proscenium wall of reinforced concrete only 4 ins. thick. This wall is shown in one of the sections, and is reinforced near the top by two horizontal ribs 6 × 12 ins. On this floor are also some reception rooms and other rooms for Masonic purposes. On the fourth floor is the Chapter and Council Room, together with some other reception rooms.

The fifth floor consists partly of galleries for the Commandery Hall and the Chapter and Council Room, and has also some reception rooms. Over the Commandery Hall and Chapter and Council Room is a suspended ceiling forming an attic, in which is also suspended a steel tank of 25,000 gallons capacity. The roof has an inclination of only 8 ins. in 50 ft., shedding the water to all four corners of the building. It is of 4-in. concrete, covered with a 1-in. layer of asphalt, and will be used as a roof garden.

The construction of the basement and first floor did not offer anything unusual in design. They are supported by columns 12 ft. and 16 ft. c. to c., which columns are connected by 8 × 10-in. girders. The floor slabs are only 3½ ins. thick, reinforced by steel rods laid in both directions. Most of the floors are ribbed, but over the library there is a hollow concrete floor of 25 ft. span, 12 ins. deep; this consists of a flat ceiling 1½ ins. thick and a floor 2½ ins. thick, with ribs 5 ins. wide and spaced about 3 ft. c. to c. Each rib is reinforced by two steel rods 1⅛ ins. in diameter.

As shown by the sections, the Blue Lodge Room and the Assembly Hall are spanned by girders of 47 ft. unsupported length. While the girders over the Blue Lodge Room have relatively little to carry, and were made 14 ins. wide and 38 ins. deep, those over the Assembly Hall had to carry 250,000 to 350,000 lbs., and were made very heavy, 18x42 ins. Each of these latter girders had to support the third and fourth floors, two galleries, a girder, and also the property room and the columns of the fifth floor.

With these heavy concentrated loads it was necessary that the loads should be carried by columns in the exterior walls down to the footings. In Fig. 1 it will be noted that the girders of the third floor had to support the columns for the fourth floor. The possibilities of reinforced concrete construction are indicated in Fig. 2, where a 4-in. partition wall is shown carrying three floors

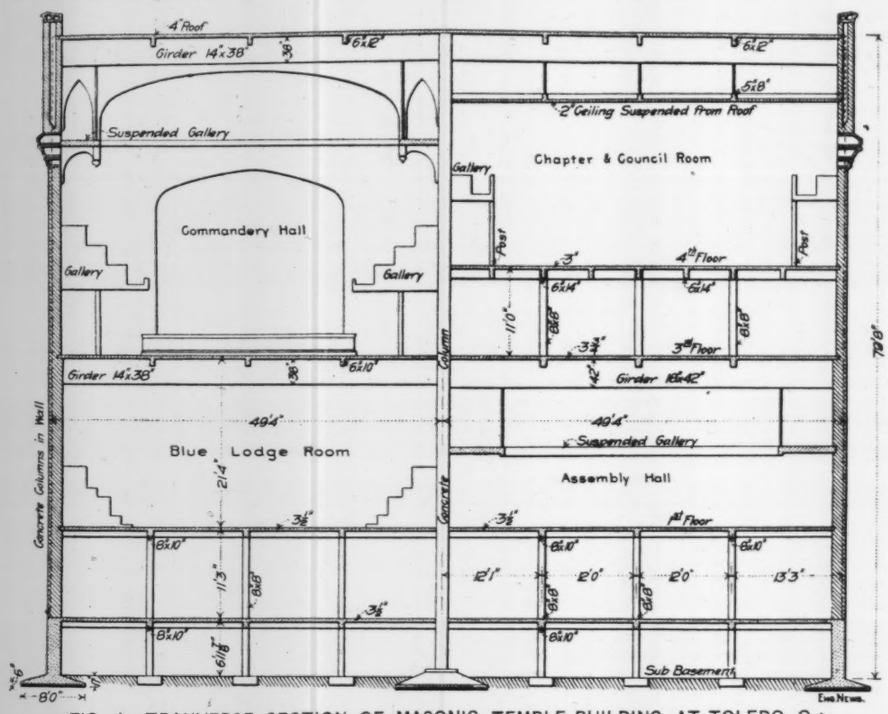


FIG. 1. TRANVERSE SECTION OF MASONIC TEMPLE BUILDING, AT TOLEDO, O.; REINFORCED CONCRETE CONSTRUCTION.

Harry W. Wachter, Toledo, Architect; A. Bentley & Sons, Toledo, Builders; L. J. Mensch, Chicago, Consulting Engineer.

on one side and one floor on the other side. Although these floors were figured for only 80 lbs. per sq. ft., one of the floors was tested to 250 lbs. without producing any sign of undue stress in the 4-in. partition wall. Typical girders and columns are shown in Figs. 3 and 4, but the actual construction varied according to the loads and spans, etc.

The centering for the concrete work was built in the usual way, consisting of 2-in. dressed lumber held together with nails and clamps. The floor boards were also of 2-in. lumber. The concrete was mixed by a Smith mixer in the proportion of 1 part of Castalia cement, 2 parts of sand and 4 parts of crushed stone. Only plain round rods of mild steel were used as reinforcement, and in the floors these rods were 4 to 7 ins. apart, laid in both directions.

It is stated that although the dimensions of all the structural parts were smaller than have been used before in this country, the strength of the building is entirely satisfactory. The 3½-in. floor slabs of the first and second stories were, during the building operations, repeatedly loaded with sand, stone or brick equivalent to a load over wide areas of 300 to 400 lbs. per sq. ft. Heavy hoisting engines were worked on these floors, and no sign of cracks could be found, although the concrete construction was exposed during the severe winter of 1903-1904. The heavy girders in the ceiling of the Assembly Hall and the Blue Lodge Room were tested by supporting upon them the centering of all the upper floors while the concrete was being laid, which is equivalent to a distributed weight of 150 to 250 lbs. per sq. ft.; they were figured for a load of only 80 lbs. per sq. ft. The builders made a test on Dec 5, 1904, by piling 170,000 lbs. of sand in bags, straight across the building on one panel; they put deflectometers in the center of each girder (carrying about 85,000 lbs.), but were unable to get any deflection under this load.

In the center of the building a timber tower was erected about 15 ft. square and heavily braced. From two corners of this tower two 70-ft. derrick booms were operated; one for placing the stones for the outside walls of the building, the other for hoisting the concrete in buckets of ¾ cu. yd. capacity and swinging these buckets around to the place where the concrete was to be deposited. Fig. 5 shows a part of this tower, with the boom and concrete bucket filling in one of the floors.

The architect was Mr. Harry W. Wachter, of Toledo; and A. Bentley & Sons, of Toledo, were the contractors. Mr. L. J. Mensch, Monon Building, Chicago, was the Consulting Engineer, and we are indebted to him for plans and other information.

THE EFFECT OF FLUE GASES AND MOISTURE ON CONCRETE.

The following notes concerning the behavior of concrete flues and stacks subjected to hot gases from metallurgical works have been submitted by Mr. Francis T. Harvard, of Silberhütte, Anhalt, Germany, as discussion of the paper on "Concrete in Mining and Metallurgical Engineering," read by Mr. Henry W. Edwards at the Atlantic City meeting of the American Institute of Mining Engineers in February, 1904. The notes relate to experience at the plant of the Anhaltische Blei-und-Silber-werke, and were presented at the Lake Superior meeting of the Institute in September, 1904:

The flues and smaller stacks at the works were constructed of concrete consisting generally of one part of cement and seven parts of sand and jigtailings, but in the case of the under-mentioned metal-concrete slabs, of one part of cement to four parts of sand and tailings. The cost of constructing the concrete flue approximated 5 marks per sq. m. of area (equivalent to $0.11 per sq. ft.).

EFFECT OF HEAT.—A temperature above 100° C. caused the concrete to crack destructively. Neutral furnace-gases at 120° C., passing through an independent concrete flue and stack, caused so much damage by the formation of cracks that, after two years of use, the stack, constructed of pipe 4 ins. thick, required thorough repairing and auxiliary ties for every foot of height.

EFFECT OF FLUE GASES AND MOISTURE.—The sides of the main flue, made of blocks of 6-in. hollow wall-sections, 100 cm. by 50 cm. in area, were covered with 2-in. or 1-in. slabs of metal-concrete. In cases where the flue was protected on the outside by a wooden or tiled roof, and inside by an acid-proof paint, consisting of water-glass and asbestos, the concrete has not been appreciably affected. In another case, where the protective cover, both inside and outside, was of asphalt only, the concrete was badly corroded and cracked at the end of three years. In a third case, in which the concrete was unprotected from both atmospheric influence on the outside, and furnace-gases on the inside, the flue was quite destroyed at the end of three years. That portion of the protected concrete flue, near the main stack, which came in contact only with dry cold gases was not affected at all.

Gases alone, such as sulphur dioxide, sulphur trioxide, and others, do not affect concrete; neither is the usual quantity of moisture in furnace-gases sufficient to damage concrete; but should moisture penetrate from the outside of the flue, and, meeting gaseous SO_2 or SO_3, form hydrous acids, then the concrete will be corroded.

EFFECT OF THE ATMOSPHERE ALONE.—For outside construction-work, foundations and other structures not exposed to heat, moist acid-gases and chemicals, the concrete has maintained its reputation for cheapness and durability.

EFFECT OF CRYSTALLIZATION OF CONTAINED SALTS.—In chemical works, floors constructed of concrete are sometimes unsatisfactory, for the reason that soluble salts, noticeably zinc sulphate, will penetrate into the floor and, by crystallizing in narrow confines, cause the concrete to crack and the floor to rise in places.

THE LARGEST ELECTRIC MOTOR ever built is claimed to be a synchronous motor of 8,000 HP. rating, built by the Allis-Chalmers Co. for the Shawinigan Water & Power Co., of Shawinigan Falls, P. Q., Canada. The motor is half of a motor-generator set which is used as a frequency-changer. The speed of the machine is 300 r. p. m. Motor and generator are of the revolving-field type, with external stationary armature. They are on a

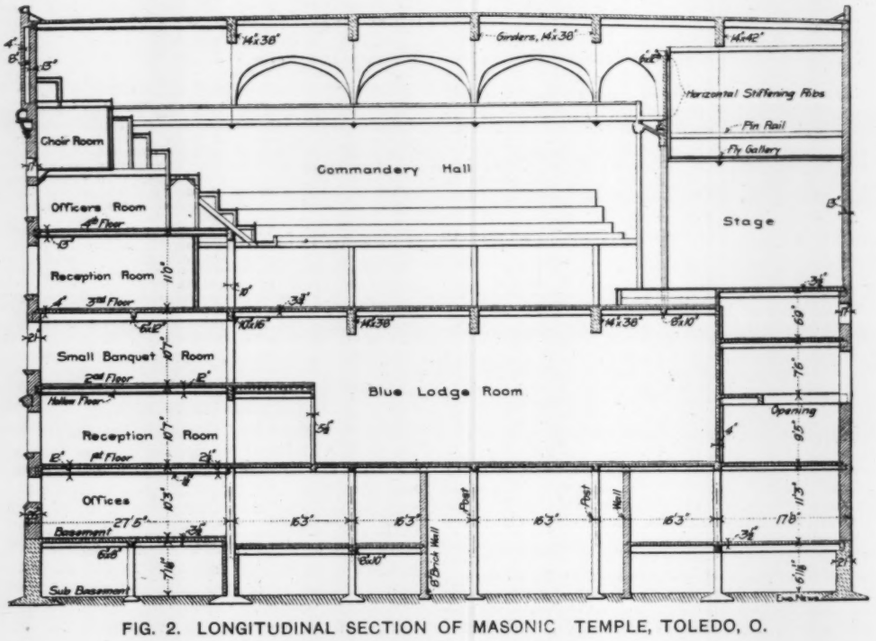


FIG. 2. LONGITUDINAL SECTION OF MASONIC TEMPLE, TOLEDO, O.

common shaft resting in three bearings, one at each end and one between the two machines. The whole set rests on a single bed-plate.

SEPARATE CONTRACTS for furnishing gas for street lamps and for the care and maintenance of mantles have been recommended by the Merchants' Association of New York City to Commissioner Oakley, head of the Department of Water Supply, Gas and Electricity. New York now pays $24.75 per lamp per year for Welsbach street lights burning 3 cu. ft. of gas per hour for 3,925 hours per year. As the actual gas consumed is only 11,775 cu. ft. per lamp per annum, its total value at 90 cts. per M. ft. (the price fixed by law for gas as sold to the city) is $10.59. This leaves $14.59 as the price paid by the city for care and renewal of mantles and for lighting and extinguishing lamps. In Baltimore, where separate contracts for furnishing gas and for care of the lamps are in force, the city pays only $9 per lamp per annum for mantle renewals and care. In New York City mantle

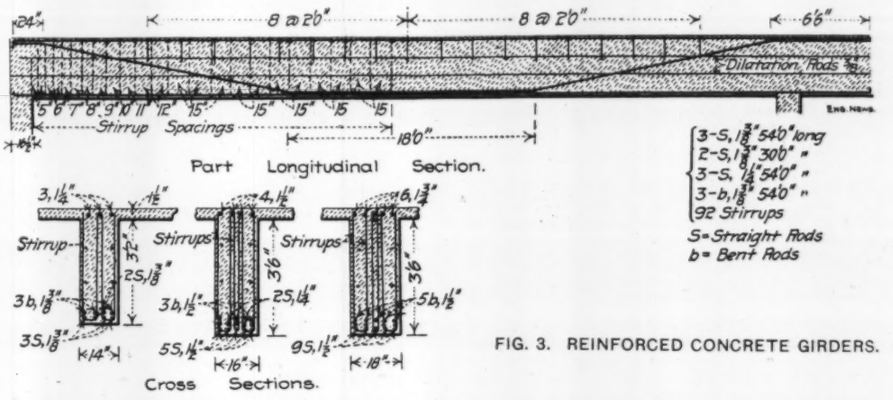


FIG. 3. REINFORCED CONCRETE GIRDERS.

lamps are to replace the flat flame burners entirely in the future, and a saving in the rate on the 30,000 gas lamps in service will be of large importance.

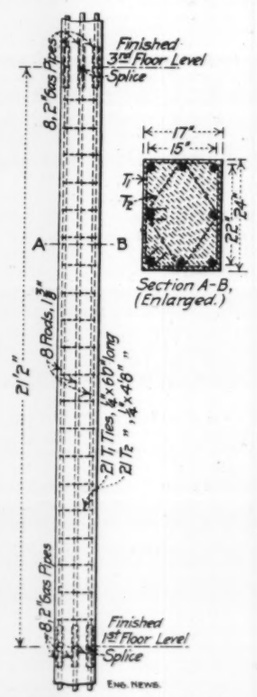


Fig. 4. Reinforced Concrete Columns.

AN ELEVATED RAILWAY ACCIDENT which narrowly escaped being a serious disaster occurred in Chicago on March 7. The Chicago & Oak Park Ry. (formerly the Lake St. Ry.) has a short branch extending south on Market St. to the old terminal at Market and Madison Sts., which was used before the elevated loop line was built. A few trains daily, being worked as shuttle trains between the Canal St. and Madison St. stations. As a two-car train was taking the sharp curve from Lake St. to Market St. the rear truck of the rear car kept to the straight track on Lake St., and the car was overturned and lay on its side, with one end on the branch and the other end on the main track. A number of passengers were cut and bruised, and one was caught under the car so that it was an hour or more before she could be removed; but, fortunately, her injuries were not serious. Several persons narrowly escaped falling through to the street, and some of those near the middle of the car were rescued by firemen with the aid of ladders. Others crawled through the windows and walked back on the structure. The superintendent reported, after an investigation, that the switch had been thrown before the rear truck had cleared it, but the switchman could not be found by the police.

THE BREAKING OF A HOISTING ROPE in the Cold Spring Colliery, at West Pittston, Pa., March 9, caused the death of seven men. The cage fell 250 ft.

A SERIOUS RAILWAY ACCIDENT occurred on the Pittsburg, Fort Wayne & Chicago division of the Pennsylvania Lines near Clifton, Pa., on March 3. The second section of a through passenger train going east ran into the first section while the latter was stalled by a hot box. Parts of both sections were wrecked, and seven passengers were killed outright. Additional trouble arose from the wreckage catching fire. The accident was at first charged to the automatic signals; the engineer of the second section stated that the signal directly back of the point of collision showed clear. The railway company's investigation resulted in a report which laid the blame entirely upon the engine-crew of the second section:

The signal system was in perfect working order. The cause of the accident was the failure of the engineman to observe the rules of the company. The signal at Dixmont, 3,744 feet west of the standing train, displayed a green or caution signal to the approaching train. This indicated that the track between Dixmont and Clifton was clear, but that there was a train in the block east of Clifton, and that third No. 6 must approach prepared to stop. The signal at Clifton displayed a red, or stop, indication. The engineman stated that because of the drifting smoke he did not see the Dixmont signal and proceeded at full speed until within 1,000 feet of the standing train when he saw the rear lights, but the distance was too short. The engineman has been dismissed.

HUMIDITY IN HEATED HOUSES has been the subject of observations during the past year by Prof. R. C. Carpenter, of Cornell University, Ithaca, N. Y. The observations were made in his residence, which is heated by direct steam radiation. He found that the humidity of the air in the house, during the first half of the present winter, ranged from 18% to 35% averaging, perhaps, close to 25%. The humidity of the outside air, during the same period, ranged from 60 to 80%, averaging about 70%. As Prof. Carpenter says, the observations show that the air in his house is "extremely dry, probably drier than that in most deserts." These results are identical with results of similar observations made by Dr. H. M. Smith, of New York City, some years ago, and reported in a paper read before the Brooklyn Medical Society. Dr. Smith found that in an ordinary heated house the humidity through the winter of 1902 to 1903 was 24 to 30%, while in the same period the average humidity of the outside air was about 73%. He also made an experiment by keeping two adjoining rooms in a different moisture condition, one being at the normal heated-house humidity, while the other by artificial moistening had its humidity maintained at about 60%, which Dr. Smith calls "proper degree of humidity." The room with greater moisture was, moreover, maintained at a slightly lower temperature, 65 to 68° F., than the dry room, which was kept heated to 72° F., its humidity being about 30%. By getting opinions on the relative temperatures or degrees of comfort of the two rooms, from various visitors who were told nothing of the experiment, Dr. Smith found that the room with greater moisture was estimated to be at least 2° warmer than the dry room. He concluded from his experiments that, with a proper degree of moisture, say 60%, a room-temperature of 65° F. is comfortable, 68° is warm, and 70° is rather too warm. With rooms as dry as heated houses ordinarily are in winter, a temperature of 72 to 73° F. is none too warm, and even this always leaves the impression of drafts of air.

A NEW ELECTRIC INCANDESCENT LAMP, having a filament made of the metal tantalum, has been developed by Messrs. W. von Bolton and O. Feuerlein, of the Siemens-Halske Co., of Berlin, Germany. In seeking for a metal capable of withstanding a very high temperature—for the luminous efficiency increases rapidly with the temperature—Mr. von Bolton tried vanadium, niobium and tantalum. The former two proved too low in melting point. Tantalum was reduced from potassium tantalofluoride to a metallic powder, which by fusing in a vacuum became very pure. The fused metal can be hammered and can be drawn to very fine wire. The metal is not attacked by any cold acid except hydro-fluoric. Heated in air it changes color like steel. It absorbs hydrogen and nitrogen eagerly at low red heat, and also

FIG. 5. VIEW SHOWING FLOOR CONSTRUCTION OF MASONIC TEMPLE BUILDING OF REINFORCED CONCRETE, AT TOLEDO, O.

combines easily with carbon, forming brittle carbides. The pure metal has a specific gravity of 16.8, hardness about the same as mild steel, tensile strength greater than that of steel, specific electric conductivity 6.06 times as great as that of mercury, at ordinary temperature. At the temperature of the incandescent (tantalum) lamp, however, its resistance is just 5 times its cold resistance. Between 0° C. and 100° C. its temperature coefficient is 0.30, being positive. Its coefficient of linear expansion, between 0°C and 60° C. is 0.000,0079. Its specific heat is 0.0365. Drawn into fine wire its tensile strength is 135,000 lbs. per sq. in. Used for incandescent lamps at 110 volts and 32 c. p., the tantalum filament requires to be 700 mm. long by about .002-in. diameter. The production of a wire of these dimensions was the first difficulty, which was overcome by careful working. The arrangement and support of such a filament in an incandescent lamp bulb was the next problem. This problem was the more difficult in view of the fact that the tantalum softens appreciably over quite a range of temperature before fusion, and is already considerably softened when at the temperature necessary to give a lighting efficiency of 1.5 watts per candle power. The plan of looping the filament as in the ordinary incandescent lamp was for this reason not applicable. The solution was found in arranging a central reel-like support, on which the filament was run up and down on elements of a cylinder, like the wave-winding of a dynamo armature. On this basis a standard lamp for 110 volts, 25 c. p., 1.5 watts per candle power, was developed, having a filament 650 mm. (26 ins.) long by 0.05 mm. (0.002-in.) diameter. The properties of this lamp are: At the same voltage and the same useful life it consumes only half the current required by the ordinary carbon filament incandescent lamp for equal light. Or, for equal current consumption, its useful life is several times as long. A sufficiently long life, 400 to 600 hours for 20% decrease in illumination, is attained at a power consumption of 1.5 watts per candle power, which has therefore been adopted as standard (the ordinary carbon filament lamp consumes 3.1 to 3.5 watts per candle power). These lamps are very resistant to shock, etc., when new, but after being in use for several hundred hours the filament becomes much more brittle. The tantalum lamp is, however, not so sensitive to increase in voltage as is the carbon filament lamp, largely because tantalum has a positive temperature coefficient while that of carbon is negative. Further, tantalum does not blacken the bulb as much as the carbon filament. The lamp appears to have a great future, since tantalum ores exist in sufficient abundance to supply the required metal. For the present, Siemens & Halske will manufacture only the 25-candle 110-volt lamp, which has been successfully developed. The lamp and its development were described by Messrs. v. Bolton and Feuerlein before the Elektrotechnischer Verein of Berlin a few weeks ago. A reprint of their paper is given in "The Electrician" of London in its Jan. 27 issue.

THE HUDSON RIVER TUNNEL TERMINAL subway franchise has been approved by Mayor McClellan, of New York City, after its passage by the Board of Aldermen. The subway is therefore ready to be constructed at once. It will be a vital part of the Hudson River Tunnel, the enterprise which was begun nearly 30 years ago and is only now, after many vicissitudes, nearing completion. The twin river tunnel reaches the New York bank at about Christopher St., about three miles north of the southern end of Manhattan Island. The subway extension will be a loop running eastward to Second Ave., and a line branching from this loop up Sixth Ave. to 33d St.

NOTES FROM THE ENGINEERING SCHOOLS.

LEHIGH UNIVERSITY.—The attendance at the University is now 630, which is the largest in its history. The graduates of the University number 1,400.

MICHIGAN COLLEGE OF MINES.—The student body at present approximates 200. Of the 283 graduates of the College, only 5 have left the profession for which they were trained, which is a record that probably no other professional school can equal.

PERSONAL.

Mr. George I. Leland has been re-elected City Engineer of Lynn, Mass.

Mr. David N. Cook has been elected Superintendent of the Water Department of Salem, Mass.

Mr. George F. Morse has resigned his position as Chief Engineer of the Missouri, Oklahoma & Gulf Ry.

Mr. Albert S. Burnham has been appointed Superintendent of the recently acquired water-works of Revere, Mass.

Mr. George H. Rutledge has been appointed Superintendent of the Municipal Water and Electric Light Plant of Concord, N. C.

Mr. J. L. Crider has resigned as Assistant Engineer of the Baltimore & Ohio R. R., at Hazelwood, Pa., to accept a position elsewhere.

Mr. L. C. Fritch has been appointed Assistant to the General Manager of the Illinois Central R. R. Co., with headquarters at Chicago, Ill.

Mr. A. Lincoln Fellows has resigned his position as District Engineer of the U. S. Reclamation Service to accept a position as State Engineer of North Dakota.

Mr. Charles A. Hague, M. Am. Soc. C. E., will, on May 1, move his consulting engineering offices to 52 Broadway, Exchange Court Building, New York City.

Mr. F. W. Bailey has been appointed Superintendent of Bridges and Buildings of the Missouri, Kansas & Texas Ry., with office at Denison, Tex., vice Mr. A. B. Manning, deceased.

W. H. Burr M. Am. Soc. C. E., Professor of Civil Engineering at Columbia University, has been appointed Consulting Engineer of the Aqueduct Commission of New York City.

Mr. H. B. Stoner has resigned as Assistant Engineer of the Northern Pacific Ry., to accept a position as Chief Engineer of the Spokane Valley Land & Water Co., at Spokane, Wash.

Mr. Frank M. Baker, New York State Railroad Commissioner, recently sustained the loss of five toes on his left foot, while trying to board a moving train at Port Jervis, N. Y.

Mr. D. H. Whitmer, M. Am. Soc. C. E., has accepted a position as Chief Engineer of the International Water Co., of El Paso, Tex., and will be in charge of a new system of water-works for that city.

Allis-Chalmers Co., of Milwaukee, Wis., will be represented hereafter in West Australia by Mr. F. R. Perrot, of Perth, and in New Zealand, by the firm of John Chambers & Son, Ltd., of Auckland.

Mr. I. O. Walker, Assistant Engineer of the Paducah and Memphis Division of the Nashville, Chattanooga & St. Louis Ry., and Miss Ionia L. Desha were married March 6 at Paducah, Ky. They will reside in Paducah.

Mr. B. A. Schroeder, for some time attached to the St. Louis office of the Crocker-Wheeler Co., has been placed in charge of the New Orleans office of the company. Mr. Schroeder succeeds Mr. W. P. Field, who has been transferred to the Boston office.

Mr. Henry M. Sperry, M. Am. Soc. C. E., has been appointed Consulting Signal Engineer for the Hudson Co.'s, a consolidation of interests constructing two lines of tunels under the Hudson River at New York, with a connecting subway line near Eighth Ave., New York.

Mr. Elmer E. Barnard, Jun. Am. Soc. M. E., of Lynchburg, Va., and Miss Belle C. Smith, of Knoxville, Tenn., were married Feb. 27 at Washington, D. C. Mr. Barnard at present is Assistant to the Chief Engineer on the installation of the new gravity water supply for Lynchburg.

Mr. David M. Duller, of Houston, Tex., has been appointed Chief Engineer for the Houston-Galveston Electric Railway and has begun his surveys for the line. Mr. Duller is also Chief Engineer for the American Rice Cereal Co., and at the last meeting of the Directors he was elected Secretary of the company.

Mr. H. J. Barron, who for some years has been engaged in New York City in the design and installation of heating and ventilating plants, is now in the employ of the Green Fuel Economizer Co., at its New York office, 74 Cortlandt St., and will give his attention to the sale of blowers, heaters, ventilating fans, etc., to the trade.

Mr. D. W. Cole has been appointed Constructing Engineer in the U. S. Reclamation Service and will have charge of the construction of a large masonry dam in Shoshone River Canyon, near Cody, Wyo. Mr. Cole formerly was connected with water supply surveys and construction for the cities of New York, Boston, Mass., and Waterbury, Conn.

Mr. John L. Mann, Assoc. Am. Soc. C. E., has severed his connection with the Thayer School of Civil Engineering of Dartmouth College as Associate Professor of Civil Engineering, to accept a position in the U. S. Reclamation Service, and for the present will be under Mr. Raymond F. Walter on the Belle Fourche Irrigation Project in South Dakota.

Mr. A. S. Fairbanks and Mr. H. A. Moody, lately engineer for the Union Bag & Paper Co., have formed a partnership under the firm name of Fairbanks & Moody, and will make a specialty of general industrial engineering, the designing and construction of paper and pulp mills particularly, and hydraulic development. The offices of the firm will be at 150 Nassau St., New York City.

Mr. R. R. Keely, heretofore Assistant Professor in the Department of Engineering of the University of North Dakota, has become connected with the firm of Symms & Powers Co., Heating and Ventilating Engineers, of Sioux Falls, S. Dak., and will have charge of their engineering department. Mr. Keely was graduated from Cornell University in the class of 1901. Mr. Keely will begin his new duties April 1.

Mr. D. M. Fraser, formerly Assistant Engineer, Victorian Railways of Australia, is now in charge of the Johore State Railway survey under engagement to the Government of the Federated Malay States. Johore State is under an independent Sultan, but is contiguous to the Federated Malay States which are under British Sovereignty. The two governments have entered into an agreement for the construction of a railway to the southerly point of the Malay Peninsula. Mr. Fraser's address is Johore Bahm via Singapore.

Obituary.

George G. Cochran, Assistant to the President of the Erie R. R., died March 13 in New York City after an operation for appendicitis.

A. J. Taylor, of Florence, Mass., Chief Engineer in charge of the filter plant at Burlington, Ia., died March 2 in that city from heart disease.

Emmet Smith, formerly City Surveyor of Bayonne, N. J., died suddenly March 11 at his home in that city from heart disease. Mr. Smith had been City Surveyor for 32 years, resigning that position about two months ago. He was 56 years old.

M. F. Smearman, inventor of the first pneumatic ash hoist, with portable buckets located in the ash pit, died recently at Warren, Pa., aged 34 years. Mr. Smearman was one of the most skillful draftsmen in the employ of the Pennsylvania R. R.

W. W. King, General Superintendent of the Norfolk & Southern R. R., died March 8 at Norfolk, Va. Mr. King was born in Geneva, N. Y., in 1854, and after assisting with building of the Manhattan Railroad in New York, came to the Norfolk & Southern R. R.

D. H. Conklin, former Mayor of Decatur, Ill., died March 10 at his home in that city. In the early 70's Mr. Conklin was President and General Manager of the Illinois Central R. R., having his headquarters in Decatur. He retired from active railroad service several years ago. He was 74 years old.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21, 22, 23. Annual meeting at Chicago. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committee, W. F. Allen, 24 Park Place, New York.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
May, 1905. Annual spring convention, at Scranton, Pa. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the meeting of the Electrical Section on March 9 a paper was read by Mr. J. S. Stone on "Electrical Resonance in Wireless Telegraphy."

ENGINEERS' CLUB OF PHILADELPHIA.—At the next meeting, to be held on the evening of March 18, Mr. W. L. Webb will read a paper, entitled "Reinforced Concrete; Some of Its Principles, with Practical Applications." The paper will be illustrated with lantern slides.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The subject of discussion at the March meeting of the Institute, to be held at 154 West 57th St., on the evening of March 24, 1905, will be High-Potential Electric Railway Work. Three papers on the subject are announced: "Line Construction for High-Pressure Electric Railroads," by Mr. G. A. Damon; "High-Pressure Line Construction for Alternating-Current Railways," by Theodore Varney; "Application of High-Pressure to Electric Railroads," by Ernest Gonzenbach.

NEW YORK AND CHICAGO ROAD ASSOCIATION.—The second annual convention of the New York and Chicago Road Association, in conjunction with the Southern Tier Good Roads Association, will be held at Elmira, N. Y., on March 21 and 22, 1905. The convention will be called to order at 10 a. m., March 21, in the City Hall, by its president, Col. A. A. Pope, of Hartford, Conn. On the evening of the same day a banquet will be served. All persons interested in the objects and work of the association are invited to attend.

The New York and Chicago Road Association is primarily engaged in promoting the construction of a highway between New York and Chicago, but in second rank it aims to arouse sentiment in favor of improved roads generally. The projected route of the New York and Chicago road is: North from New York along the east bank of the Hudson to Rhinecliff, thence west to the south shore of Lake Erie at Westfield, N. Y., thence along the south shore through Erie, Pa., Ashtabula, Cleveland, Lorain, Sandusky and Toledo, O., thence westerly through Goshen, Elkhart, South Bend, Laporte and Hammond, Ind., to Chicago, Ill. Through New York State the line of the road passes through the whole length of the "Southern Tier" of counties, which explains the participation of the Southern Tier Good Roads Association in the convention. Mr. A. H. Battey, 154 Nassau St., New York, is secretary of the New York and Chicago Road Association, and Mr. W. L. Dickinson, Springfield, Mass., is chairman of the executive committee.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, March 16, 1905.

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In the study of Applied Mechanics the division of stress into two kinds: Normal and Tangential, and the farther classification into 1. Compression, 2. Tension and 3. Shear, are quite satisfactory. In the actual use of the science, by the designer of structures, this classification is also generally sufficient. Supplemented by a statement of location, direction, or other qualification of the stress-condition spoken of, the three simple stress names suffice for nearly all purposes. Thus, a steel plate-girder is designed by equating the known safe resisting values of the material to the tensile stress in the lower flange, the compressive stress in the upper flange, the transverse shear (web and splices), the longitudinal shear (flange-rivets), etc. In other than steel construction the three fundamental names are equally sufficient in most cases. A case recently came to our notice, however, in which an additional name seems desirable.

In a beam or other structure of reinforced concrete we have to deal with: (1) Compressive (and sometimes also tensile) stress in the concrete; (2) Tensile stress in the steel; (3) Shearing stress in the concrete; and (4) Stress tending to break the bond between steel and concrete by slipping the steel bars through the concrete. The last-named is, broadly, a tangential stress, that is a shear, although it may be resisted by other phases of stress, as when the bar has projections which bear against the concrete in direct compression. But it does not seem desirable to use the word shear for the purpose, as it is better to reserve this term for a tangential stress within a single material. Yet a short term is called for, to avoid the awkward necessity of speaking of "the stress tending to slip the steel in the concrete."

What name is available for this purpose? Various terms: Adhesion stress, Sliding stress, Slipping stress, Surface stress, Stripping stress, Stripping shear, and the like, suggest themselves. An acceptable term should not attempt to characterize the means by which the stress is resisted, since adhesive resistance, surface friction, or mechanical interlocking may act simply or together. The quantity in question is important in nearly all reinforced concrete construction, and will be more frequently spoken of and used in calculation as such work spreads; the adoption of a fitting and expressive term is, therefore, inevitable, whether it comes about by chance or by conscious selection.

Prizes Offered for the Best Paper on Concrete Blocks.

The two most important applications of concrete in building construction at the present day are first, reinforced concrete, and second, concrete block construction. Concerning the first, a vast amount of literature is available and the engineer desiring information finds technical periodicals and proceedings of engineering societies full of articles on reinforced concrete, while several excellent books are also available.

Concerning the second, concrete block construction, however, there is an absolute dearth of literature, and at the same time a great demand for information. Not a day passes but there come to this office requests for advice or information concerning concrete block manufacture or construction. There is good reason to believe that concrete blocks may be quite as important a factor in future building construction as reinforced concrete. The field of the two materials is of course quite different. Reinforced concrete is used for columns, girders and floors in place of wood or steel construction. Concrete blocks are used for wall construction in place of brick or terra cotta or stone. Reinforced concrete finds its chief field in the construction of factories, warehouses, stores and similar large structures. Concrete blocks however are also adapted for use in buildings of moderate size, and as these outnumber the large buildings ten to one, or even a hundred to one, the field for concrete block construction is really an enormous one.

There are now springing up all over the country local plants for the manufacture of concrete blocks. A considerable number of engineers who have become tired of working on a salary or of grappling with the uncertainties of independent practice, are looking into the matter of concrete block construction, with a view to establishing such local plants; but before investing their savings in the business they naturally desire to learn all the facts they can concerning it; and to learn them, moreover, from unprejudiced sources.

The first question of all to be settled is what sort of plant is required to successfully manufacture these blocks. The engineer finds on the market a large variety of machines for concrete block manufacture, each claiming points of superiority over its rivals, while charges and counter-charges of patent infringement are bandied back and forth between the rival manufacturers. Which machine, or what type of machine shall the engineer select? What value may he place on guarantees of exclusive "territory" that may accompany the machine?

Nor does the engineer's desire for information end with the selection of a machine. What material shall be used? Should blocks be made on the site of a building or at a yard where the materials can be best assembled? Is waterproofing necessary, and how shall it be done? What cost figures have been attained in actual practice? What guarantee as to strength, waterproofness, etc., is it safe to give? These are but samples of the hundreds of questions which are confronting engineers and others who are investigating propositions for concrete block manufacture.

We desire to present to our readers some first-class literature in this field; and in order to stimulate its production, we have decided to establish a prize competition. With the many concrete block plants now in actual operation in all parts of the country, such questions as we have outlined above must have been thoroughly investigated by a good many engineers. We wish to encourage such engineers to make public the results of their investigations, and we trust that our prize offer may have this effect. Our formal offer of prizes is as follows:

The Engineering News Publishing Co. offers two prizes, a first prize of $150 and a second prize of $75 for the best papers on the following subject:

"THE MANUFACTURE OF CONCRETE BLOCKS AND THEIR USE IN BUILDING CONSTRUCTION."

The merit of the papers will be judged chiefly from the standpoint of their practical usefulness to an engineer who proposes to establish a local business in the manufacture of concrete blocks. If the papers are carefully prepared and founded on experience, as we hope may be the case, they will constitute an invaluable guide to any one proposing the establishment of such a plant or proceeding with its operation.

The length of the paper should be not less than 5,000 words and not more than 10,000 words. It may be accompanied by any drawings or photographs which the author deems necessary for its illustration.

All manuscripts must be typewritten and must be received at the New York office of this company not later than May 31, 1905. They must be signed with some nom de plume and accompanied by a sealed envelope bearing on its outside the nom de plume and inside the name and address of the author of the paper. Manuscripts and all accompanying matter should be sent fully prepaid, by express or registered mail, since their receipt by us cannot be acknowledged in the ordinary manner. They should be marked on the outside of the wrapper, "For the Concrete Block Prize Competition."

As soon as possible after the close of the competition, the manuscripts will be examined by the editors of Engineering News, and from the whole number offered, the five best manuscripts will be selected for submission to a jury consisting of Messrs. Robert W. Lesley, late President of the American Cement Manufacturers' Association; Richard L. Humphrey, President of the Cement Users' Association, and Prof. Edgar Marburg, Secretary of the American Society of Testing Materials. In case the editors experience difficulty in making the primary selection, a larger number of manuscripts than five may be submitted to this jury.

As soon as a selection is made by the jury, the sealed envelopes will be opened and public announcement made of the result of the competition. The prize articles will be published in Engineering News, and the right is reserved to publish also any other articles submitted in the competition and not awarded a prize, or any portions of such articles, paying the author for the matter so used at our regular rates for contributed articles. The right is also reserved to copyright the prize articles or others accepted for publication; and the matter may be later published in book form.

We desire also to call especial attention to the field which is open here for engineers competent to give advice as to the construction, equipment and operation of concrete block making plants. That there are such engineers somewhere we have no doubt; and the problem they are facing presumably, is how to make their abilities known to the men from whom they would seek engagements. In the kindred field of reinforced concrete a number of engineers have become known, chiefly through their contributions to technical literature, as competent to give advice on reinforced concrete work, and they have in consequence built up a considerable consulting practice. The prize competition above described should give some ambitious engineer a similar opportunity to establish a professional reputation in a field of engineering work where the demand is now far ahead of the supply.

CORRESPONDENCE.

The Proper Form for Engineers' Field Books.

Sir: It may be a matter not while worrying over, but I would be glad to see the question of Engineers' Field Books discussed in your columns. I suppose there are as many ideas as there are engineers, but the main thing I have in mind is more the mechanical execution of these books, than individual ideas. Take, for instance, the catalog of the Keuffel & Esser Co., pp. 40 and 41. Here we have illustrated four types of field books. It will be noticed that in every case the vertical ruling is carried to the very top, instead of leaving a blank space for a heading. What would a bookkeeper say about this kind of ruling? Every page should have an appropriate heading, and it does not conduce to a system to have no proper space to fill in such a heading without having to write across vertical lines.

Again, why should field books not be supplied with

index pages, in both the back and front? Engineers are notoriously unsystematic, and hardly any one but the person keeping the notes understands them. It seems to me a part of the fault for this lies with the makers of the field books. Let us have field books properly ruled and supplied with proper index pages. "Recorder."

Utica, N. Y., Feb. 21, 1905.

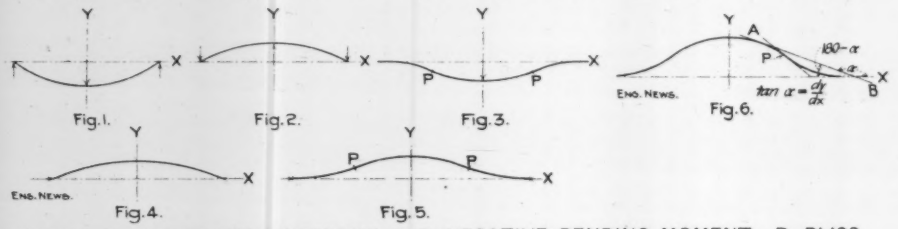
On the Sign of Bending Moment.

Sir: That "considerable confusion exists concerning the sign of bending moment," as Mr. Sanford A. Moss in his article in your issue of Feb. 16 remarks, is undoubtedly true; and that "no consistent convention is used by writers on the subject" is true in many instances. Mr. Moss' article, as he claims, shows very clearly that no such confusion should or need exist. But no new convention is required for this purpose. What is required is a definition of positive and negative bending moment which will satisfy all existing rules or conventions so that no mistake or confusion will result when dealing with the subject from a mathematical point of view. In actual affairs the idea of a positive or negative bending moment is of little importance.

Now in mathematics it is a universally accepted convention that measurements to the right of a given point are positive, to the left negative, above position and below negative. In problems on beams this applies directly: When considering columns or inclined beams imagine them horizontal before applying the rule.

Then in the following figures, considering the right-hand portion of Figs. 2, 4 and 5, it is obvious that $\frac{dy}{dx}$, the slope of the curve or the rate of change of y with regard to x is negative since y diminishes as x increases, another obvious or universal convention. For Figs. 1 and 3 $\frac{dy}{dx}$ is positive. And similarly for Figs. 2 and 4, and for Fig. 5 between the points P P, and for Fig. 3 beyond the points P P, $\frac{d^2y}{dx^2}$, or the rate of change of $\frac{dy}{dx}$ with regard to x (i. e., the slope of the curve connecting $\frac{dy}{dx}$ and x) is negative. For Fig. 1, for Fig. 3 between, and for Fig. 5 beyond the points P P, $\frac{d^2y}{dx^2}$ is positive.

This is perhaps clearer if we make use of the convention of positive and negative tangents to a curve. Then (see Fig. 6) the negative tangent A B (i. e., having negative slope) making the supplementary angle (180-α with the horizontal which is continuously increasing as x increases up to the point P, and diminishing as x increases beyond P, $\frac{d^2y}{dx^2}$ or the slope of $\frac{dy}{dx}$ with regard to x is said to be negative up to the point P and positive after.



DIAGRAMS ILLUSTRATING POSITIVE AND NEGATIVE BENDING MOMENT.—B. BLISS.

Mr. Moss obtains the reverse of this because he measures his y downwards. This is contrary to the usually accepted convention mentioned above and liable to lead to confusion.

We see therefore that the curvature of a beam (at least from the mathematical point of view; and there is no reason out of mathematics so far as I know for assuming a reverse order of signs) is positive when the beam is concave upwards and negative when concave downwards.

Now $\frac{d^2y}{dx^2} = \frac{M}{EI}$ and, E and I being positive, M is negative when $\frac{d^2y}{dx^2}$ is negative, that is, when the beam is concave downwards, and positive when the beam is concave upwards. And since $\frac{Mc}{I} = F$, I being positive and c (if we are considering the upper stress) being positive, F in the upper flange, if the beam is concave downwards, is negative and indicates tension; and on the lower flange, c being negative, F is positive and indicates compression; which are the usually accepted conventional signs for tension and compression.

It is to be understood that the definition for deflection at any point of a beam is displacement of that point from a line connecting the ends of a beam or column. Its amount is the essential, its direction is unimportant, whether considered from the practical or the mathematical point of view. In the case of the cantilever only does this definition need to be considered.

Yours truly, B. Bliss.

118 West 47th St., New York, N. Y., Feb. 17, 1905.

A Home-Study Course for Machinists and Others.*

By Ernest McCullough.

In mentioning certain books as suitable for self-instruction, I wish the following to be borne strictly in mind: (1) That I do not believe, and do not claim, the books mentioned to be the only books of their sort for a young man to study. (2) That no personal interest leads me to mention these books rather than others. (3) That I have no doubt other men will recommend other books covering the same ground which will do just as well.

What I do claim, however, is that the young fellow who wishes to pursue a connected course of home study has a hard time getting disinterested advice and spends many dollars foolishly before he finally gets on the right track. I have had a fairly good experience in teaching apprentices and selecting courses for home study and simply wish to do what I can to assist. Many men have pursued courses I have mapped out and expressed themselves as satisfied. It is better to start out with a plan and stick to it than to start out densely ignorant and change text-books every time a friend talks slightingly of the ones you have.

THE FIRST BOOK.

The first book I put in the hands of the student is "An Introduction to Machine Drawing and Design," by David Allen Low (Longmans, Green & Co.; 80 cts.).

This satisfies the man who wants to begin at once on machine drawing. To many it is like copying, and many make that complaint, but to the ones who go at it in earnest great good results. By working out the drawings they absorb a vast amount of valuable knowledge about machine parts and proportions. The young man who starts in the drafting office by inking in drawings and making tracings does a deal of copying, but the knowledge gradually soaks in.

GEOMETRY.

The machine drawing is more interesting than the doing of problems in practical geometry, but one can not go far before the need of a knowledge of geometrical construction is felt. For this reason I advise taking up the work in practical geometry at the same time and on a different night. Book 8 of Longman's New Series of Drawing Books is entitled "Practical Geometry" (postpaid is 10 cts.). It should be followed by Book 14, entitled "Plane Geometry" (12 cts., postpaid). Book 15 is entitled "Solid Geometry" (17 cts., postpaid). Have one night in the week to study this mechanical drawing and the following night for machine drawing. In this way the work is varied and becomes more interesting. If when these three small books are completed the student has become interested in that kind of study, he can take up "Descriptive Geometry," by L. Faunce (American Book Co.; $2). The study of descriptive geometry can, however, as well be taken up later.

It is a good plan when the three small books on practical geometry are completed to give the evening they took to the machine drawing, thus having two nights in the week for that.

When fair progress has been made in drawing, the student should procure "The Technic of Mechanical Drawing," by Reinhardt (Engineering News; $1). This book gives particular information about lettering and the preparation of good drawings. It is not a treatise on mechanical drawing or machine design, but is simply what the title states, a book on technic, or what we would call "the way to do it right." The student of this book will certainly know how to make a first-class drawing and finish it in the most approved manner. It, however, like the descriptive geometry, can wait if the purse of the student or his time compels economy.

MATHEMATICS.

Before he can progress farther than the elementary work on machine drawing and take up machine design, he must possess a working knowledge of mathematics. This is where the stumbling block comes in. The word "mathematics" frightens many away. Still, if any progress is to be made in these days when the self-tutored man has to compete with the graduate of well-equipped technical schools, he must know something more than mere mechanical drawing.

It is harder to select a book on mathematics for the self-tutored man than a book on any other subject. If the book is too large he will get weary, and if there are more than two books at the most be will become discouraged. Ordinary text-books contain much that the self-tutored man does not need, and much that few men need unless they are studying mathematics for the purpose of teaching the subject to others.

I recommend Castle's "Practical Mathematics" (Macmillan Co.; 80 cts.), as being adapted to the needs of self-tutored practical men. In places, however, the aid of a teacher will be almost an absolute necessity. The way to get over this difficulty is to buy Higgs' "Algebra Self Taught" (Spon & Chamberlain; 60 cts.), and use it in connection with Castle. Higgs' work is fine on explanation but shy on examples to work for the purpose of giving a man practise and making him proficient. One trouble with the study of mathematics is that most of it seems so like good common sense that a man will not trouble himself to work out all the examples; thinking he knows it well. When he does come up against a hard one in a subsequent chapter he finds himself lost.

After progressing in the study of mathematics past the solution of simple equations, the student should add a fourth night of study and not exceed the limit. Four nights in a week should be sufficient. The other two nights can be given to rest and pleasure.

On the fourth night should be taken up the study of mechanics. This should be studied in the same manner as mathematics. Go through the book once very thoroughly and then a second time to fix the facts and work out the hard examples, including the examination questions at the back. The book to take up is "The Elements of Physics," by Henry Crew (Macmillan Co.; $1.10). This book is to be studied from cover to cover.

It not only treats of mechanics, but of physical science, including electricity and magnetism. The student will need this knowledge all through life.

The student now has practical geometry, machine drawing, elementary practical mathematics and physics under way, and is supposed to be studying four nights each week about two hours per night. When one subject is completed, let him devote the night given to that to some other of the subjects he has in hand until he completes them all.

THE ADVANCED HOME COURSE.

The elementary stage completed, the student should now take up "Graphical Calculus," by Arthur H. Barker (Longmans, Green & Co.; $1.50), and follow it with "Mechanics Applied to Engineering," by John Goodman (Longmans, Green & Co.; $2). These books for Monday night.

For Tuesday take up "Materials of Machines," by A. W. Smith (McClurg & Co.; $1). and follow that with "Strength of Materials," by Mansfield Merriman (Wiley & Sons; $1).

For Wednesday night take up "The Essentials of Gearing," by G. C. Anthony (McClurg & Co.; $1.50), and follow it with "An Elementary Text-Book of Machine Design—A Study of Method, with numerous illustrations" (sold by the author, Prof. Charles Lewis Griffen, Syracuse, N. Y.; $2.50). This book is very helpful as indicating the methods by which a designer of machines goes at his work. It, however, needs for its complete understanding all the mathematics, physics and machine drawing heretofore outlined.

For Thursday night take up "Steam," by William Ripper (Longmans, Green & Co.; 80 cts.). This book is to be thoroughly studied twice. Follow it with "Steam Power Plants, Their Design and Construction," by H. C. Meyer (McGraw Publishing Co.; $2), and next "The Mechanical Engineering of Power Plants," by Professor Hutton (Wiley & Sons; $5).

This completes the intermediate stage. When the books mentioned for a particular night are finished, use that night for one of the other studies and thus keep occupied four nights in the week. It may be that after a while the four nights will be all occupied with one subject.

ADVANCED STUDIES.

When the intermediate stage is completed the student is ready for the final or senior course. He should take up first the study of engines, and for this the book is "The Steam Engine," by Professor Perry (McClurg & Co.; $3.50), and "Steam Boilers," by Professor Parsons (Wiley & Sons; $4).

Having progressed to this point, the student can be left to himself. He will have a good knowledge of mathematics and mechanics, strength of materials, etc., and be able to read any technical book published and judge for himself as to its possible value. It is quite possible he will be engaged in some specialty in mechanical engineer-

*Condensed from the "American Machinist" for Jan. 5, 1905. The greater part of the omitted portions of the paper is taken up with the difficulties encountered by those wishing to study at home owing to lack of knowledge of the best available books and lack of intelligent, kind-hearted and disinterested advisers. Some of the weak points of night schools and of correspondence schools are pointed out.—Ed.

ing and require special text-books. The head draftsman, or his employer, can no doubt guide him in a selection.

In many of the books the student will find information he has already obtained in a book previously studied in the course. He should not skip it for this reason, but study it and refer to the other books. It is well to know more than one way of presenting a subject. For example, some information on the materials of engineering may be found in nearly every book, and certain principles of mechanism will be found fully stated in nearly every book. This is no drawback, but rather an advantage for the useful review it gives.

During his whole course of systematic study it is supposed the student is a subscriber to the "American Machinist" and perhaps other technical papers and will thus keep track of current progress. When he begins his studies he should purchase for $2 "Extracts from Chordal's Letters," and read it on the cars to and from his work and on the two odd evenings in the week and at such other times as he can until he knows the book by heart.

When his drawing office experience begins he should supply himself with a copy of "The Mechanical Engineer's Reference Book," by H. H. Suplee ("Engineering Magazine;" $5).

A Standard Work on Mining Engineering.

A MANUAL OF MINING.—Based on the Course of Lectures on Mining Delivered at the School of Mines of the State of Colorado. By M. C. Ihlseng, C. E., Ph.D., Formerly Dean of the School of Mines of the Pennsylvania State College; and Eugene B. Wilson, Mining and Metallurgical Engineer. Fourth Revised and Enlarged Edition. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. 723; 340 figures in the text. $5.00.

The ordinary method of revising a text-book consists in adding a few pages here and a page there, leaving the old matter practically unchanged. We are glad to note that this revised edition is worthy of being termed a revision. Aside from the fact that it contains several new chapters and 160 pages more than the third edition, the book has been largely rewritten. The introduction of numerous side-heads greatly facilitates inspection of its contents, besides improving the appearance of the pages.

The author has collaborated with Mr. Eugene B. Wilson, who has written the chapters on Methods of Mining, Miners' Tools, Channelers, Drills and Coal Cutters, and Blasting.

Mr. Rolin W. Hutchinson has written a 30-page chapter on Electric Generation and Water Power. This chapter is, of necessity, a very condensed treatment of the subject; and the same thing may be said of many of the other chapters of the book. But for the purpose of a student who desires a bird's-eye view of the field before taking up a more exhaustive investigation, it will serve admirably.

The author has followed his previous practice of citing at the end of each chapter a long list of references to technical journals and transactions. This admirable feature could be improved by more than doubling the list of references. In glancing through the lists we note the omission of references to several excellent articles bearing upon the subjects under discussion, and a careful examination would doubtless disclose many other omissions.

The book is divided into two parts: Part I., Mining Engineering; Part II., Practical Mining. It is not clear why this division should be made. The chapter on Prospecting, for example, comes under Mining Engineering; so likewise do the two following chapters on Preparatory Work and on Methods of Mining. We may ask why Preparatory Work is more Mining Engineering than Shaft Sinking, which is placed in Part II. The fact is that we can draw no line between theory and practice, or between general principles and details, in the writing of such a book as this. It is all Mining Engineering, from the art of using explosives to the science of hoisting plant design.

One of the most satisfactory chapters in the book is the one on Methods of Mining. It is a decided improvement over the same chapter in the last edition, being almost twice as long and much more complete. We note, for example, that "The Milling System" of mining is briefly discussed. We believe that about 10% of the iron ore of the Mesabi district is mined by this system—perhaps our estimate is too high, but, in any case, it is worthy of even a fuller description than it receives. Incidentally, we may add that if the student were given some idea of the amount of ore or coal mined by the different systems, he would better appreciate their importance.

The methods of mining coal are summarized and well illustrated.

That owners of the older editions may judge where the increases in the number of pages have occurred, we append a list of chapters with the pages in each chapter. The style of treatment in this edition is the same as that in previous editions. The book is written by a professor of mining engineering for students of mining engineering. It covers so broad a range of subjects that each subject is necessarily treated briefly. The book has no American competitor, and it is superior to any other book in the English language covering the same broad field; but there are other books of narrower scope that excel it on the subjects covered by both. Ventilation, for example, is more elaborately discussed in at least two other books on that subject. Drilling and blasting are better presented in other works; and, in like manner, many of the other chapters may be said to be inferior in the presentation of details. It is, perhaps, impossible for one author, and it certainly is impossible for one volume of moderate size, to cover the whole broad field of mining in a manner wholly satisfactory to a practitioner. This book, nevertheless, should be in the hands of every student of mining engineering, for its possession will save many weary hours of lecture giving and note taking. The book, moreover, is admirably adapted to the needs of the civil or mechanical engineer who is likely to be called upon to do work in the field of mining. And there are many other classes of men who will find of great value a work that covers the whole field of mining in a concise manner, as this book does.

The following is the list of chapters and the pages allotted to each: Prospecting (18); Preparatory Work (16); Methods of Mining (53); Power Generation (40); Hoisting Machinery (39); Electric Generation and Water Power (30); Hoisting Machinery and Underground Conveyances (61); Underground Haulage Systems (38); Wire-Rope Transmission (12); The Compression of Air (28); Pumping (51); Mine Gases (19); Methods of Ventilation (36); Distribution of Air (27); The Illumination of Mines (15); Accidents in Mines (20); Shafts (31); Sinking in Running Ground (11); Timbering Rooms and Galleries (32); Driving Drifts, Tunnels and Gangways (19); Drilling and Boring Machines for Exploration (19); Miners' Tools (20); Channelers, Drills and Coal Cutters (36); Blasting (25); Glossary (5).

COAL-TESTING PLANT.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 6 × 9 ins. Bulletin No. 261, U. S. Geological Survey. Preliminary Report on the Operations of the Coal-Testing Plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. Edward W. Parker, Joseph A. Holmes, Marius R. Campbell, Committee in Charge. Pp. 172; folding and other tables.

This is one of the most valuable bulletins that the U. S. Geological Survey has issued. Although it is called a "preliminary report," it contains the results of many tests on coal from different parts of the United States. These tests cover a wide range, which can best be indicated by a summary of the contents of the bulletin, as follows:

Field Work (car and mine samples), by Marius R. Campbell; Work of the Chemical Laboratory (sampling and analyses), by U. W. Lord; Washing Tests, by John D. Wick; Steam Tests, by L. P. Breckenridge; Producer-Gas Tests, by Robert H. Fernald; Comparison of Producer-Gas and Steam Tests, by Robert H. Fernald and L. P. Breckenridge; Coking Tests, by Fred W. Stammler; Briquetting Tests, by Joseph Hyde Pratt.

We wish to call particular attention to the producer-gas tests and the briquetting tests. Every engineer interested in power development from coal should secure a copy of this bulletin.

MINES AND QUARRIES.—Pub. Doc.; Bureau of the Census, Washington, D. C. Cloth; 9½ × 12 ins.; pp. 1,123; illustrated.

This is one of the volumes of special reports of the Bureau of the Census (Department of Commerce and Labor), and its information and statistics are for the year 1902. The mining census was conducted in collaboration with the U. S. Geological Survey, the statistics being collected in connection with those required for the annual report, on the mineral resources of the United States. There is first a chapter on the plan and scope of the enquiry, followed by another giving a summary and analysis of results, from which we condense the following table:

	Number of Mines.	Number of Operators.	Number of Wage-earners.	Wages* (millions).	Value of Products (millions).
				$	$
Coal	5,986	4,528	350,329	220	367
Copper	144	144	26,007	21	51
Gold and silver.	2,992	2,992	36,142	36	82½
Iron ore	525	332	38,851	21½	65⅝
Lead & zinc ore.	559	557	7,881	4½	14½
Petroleum and nat. gas	134,477	31,489	22,230	16	102½
Stone	5,764	5,470	71,156	37⅛	70⅝
All other minerals	1,069	1,346	29,132	13	43½
Total	151,516	46,858	581,728	370	797

*The "salaries of officials, clerks, etc.," would increase each amount by about 10%.—Ed. Eng. News.

These two chapters occupy 143 pages, and are followed by individual reports for the several States and Territories, covering about 180 pages. These are followed by a detailed tabulated summary arranged by minerals and groups of minerals. Almost the entire remainder of the book (about 700 pages) is composed of about 35 special reports on individual minerals, prepared by experts, and presenting much valuable information as to the industrial and commercial development. The development in methods of obtaining, treating and refining the minerals are referred to only incidentially, but there is a special chapter on the use of electricity in mining, which is of a more technical character.

THE JOURNAL OF THE IRON AND STEEL INSTITUTE.—Vol. LXVI. Edited by Bennett H. Brough, Secretary. London: E. & F. N. Spon, Ltd. New York: Spon & Chamberlain. Leather; 6 × 9 ins.; pp. 711; nine plates; many tables and figures in the text.

This volume contains the customary review of all the periodical literature of the year relating to iron, steel and fuel production, which is an excellent feature.

The following is the list of papers that were presented during the last half of the year and their authors: The Influence of Carbon, Phosphorous, Manganese and Sulphur on the Tensile Strength of Open-Hearth Steel, by H. H. Campbell; Mining and Metallurgy at the St. Louis Exposition, by H. Bauerman; A West African Smelting House, by C. V. Bellamy; The Development and Use of High-Speed Tools, by J. M. Gledhill; The Use of Exhaust Steam, From Engines Acting Intermittently, By Means of Regenerative Steam Accumulators and Low Pressure Turbines on the Rateau System, by E. Demenge; Acid Open-Hearth Manipulation, by A. McWilliam and W. H. Hatfield; Methods for the Determination of Carbon and Phosphorus in Steel, by Baron H. von Jüptner, A. A. Blair, G. Dillner and J. E. Stead; The Application of Dry Air Blast to the Manufacture of Iron, by J. Gayley.

PRELIMINARY REPORT ON THE OHIO COOPERATIVE TOPOGRAPHIC SURVEY, NOVEMBER 15, 1903. C. E. Sherman, Inspector. Springfield, Ohio: Pub. Doc. Cloth; 7 × 10 ins.; pp. 227.

This volume contains an index map showing the progress of the topographic survey of the State of Ohio. If an appropriation of $25,000 per annum

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This volume gives the exact location of every triangulation station in the State, and a long list of bench marks with their respective elevations, which will be very useful to engineers in Ohio.

A Collection of Electrical Essays.

CYCLOPEDIA OF APPLIED ELECTRICITY.—A Practical Guide for Electricians, Mechanics, Engineers, Students, Telegraph and Telephone Operators, and All Others Interested in Electricity. Prepared by a Corps of Experts, Electrical Engineers and Designers. In Five Parts. Chicago, Ill.: American School of Correspondence. Cloth; 7 x 10 ins.; pp. 2,143; over two thousand illustrations, mostly in the text. List price, $30; Special Introductory price, $18.

Part I. Current Measurements, Wiring, Telegraph. Pp. 424.
Part II. Dynamos, Motors, Storage Batteries. Pp. 422.
Part. III. Lighting, Railways, Power Stations. Pp. 409.
Part IV. Alternating Currents, Power Transmission. Pp. 490.
Part V. Telephony, Index. Pp. 398.

In view of the use of identical title pages and prefaces for each of these five volumes, one feels grateful to find on the back of each Part of this "Cyclopedia" its consecutive number and main contents. The latter, the citation of contents, is important, as there is no scheme of arrangement, either alphabetical or logical, to guide the reader in referring to any desired part of the subject covered. The numbering of the volumes, however, is of less importance, except to distinguish them; the order of the volumes does not correspond to any definite order of arrangement, and there is no particular reason why any volume might not be Vol. I. or Vol. V.

The general purpose of the work is to present, in as much detail as possible, the science and art of the various fields of electrical engineering, both "heavy-current" and "feeble-current" work, to translate the convenient German expressions. This purpose required in the first place that all difficult mathematical reasoning should be omitted, and that other means of explanation be substituted therefor. But much more than this is required for such a purpose. Each division of the whole subject must be developed in logical, progressive manner, in order that the reasons of phenomena may be clear and that from these the reasons of actual design and construction may follow. In addition, the entire group of divisions must be arranged with reference to the progressive development of ideas in the reader's (or student's) mind, for, unless this be done, it would be necessary to preface and interlard each division with explanations of primary physical phenomena, nomenclature, and methods of reasoning. The general purpose of the present work is fulfilled as far as concerns the omission of difficult mathematics (actual or implied) and the preservation of a generally simple style; it is not fulfilled in the matter of arrangement, either of the individual subdivisions (with some exceptions) or of the complete work.

The undertaking to render fair comment on the work is made difficult by the fact that the several volumes differ greatly in the plan of treatment of their several subjects. The first volume, for example, is a collection of quite distinct pamphlets or papers, a scrap-book, as it were; the fifth volume, on the other hand, is a connected text on telephony, to which is appended a very short and not very communicative chapter on wireless telephony. Perhaps the salient features of the work, in contents and in arrangement, can be best shown by giving a summary of the contents.

Part I. contains: A sketchy general survey of electric actions and applications and simple direct-current calculations (102 pp.), in which, perhaps for greater clearness, pages 43 to 58 are bound in twice; direct-current measurements (50 pp.); hints, directions and rules for electric wiring (75 pp.); the electric telegraph (96 pp.), a detailed practical treatise for self-instruction, the best part of the volume; and miscellaneous matter on wireless telegraphy, insulators, electric welding and the telautograph (75 pp.).

Part II. contains 300 pp. on direct-current motors and dynamos, a reprint paper on motors in the machine-shop, and 65 pp. on storage batteries. Of the section on motors and dynamos, about half is devoted to illustrating and describing commercial machines; the other half sets forth in a fair degree of detail the action of dynamos and motors (separately treated), and this can be characterized as very satisfactory. The storage battery section is good as far as it goes, but is not complete on the engineering side.

Part III. gives 80 pp. on electric illumination, which is good in its description of lamps; 80 pp. on electric railways, comprehensive but superficial out of proportion to the importance of the subject; management of electric machinery (110 pp.), in which many pertinent explanations, directions and hints are given; 75 pp. on power stations, giving as much on machinery as on grouping and station arrangement, and in a rather indiscriminate way; and a reprint paper (not credited) on central stations (28 pp.), in "popular" style.

Part IV. devotes most of its space (405 pp.) to alternating-current machinery and systems. The matter included is satisfactory in character, bearing in mind the limited purpose of the work; the explanatory parts are the best, though the internal arrangement is often not consecutive or logical. A short closing chapter of 16 pp. describes the action of Hewitt mercury-vapor apparatus.

Part V. gives a survey of telephone engineering (372 pp.), with a large proportion of space devoted to line work. It is by no means a complete treatise on telephony, but comprehensive enough to suit the general purpose of the work. A closing chapter on wireless telephony is of little value.

A feature of the work is the inclusion of a large number of full-page half-tone plates illustrating electrical appliances or their application. These are placed quite at randon, but thus they serve, perhaps, to relieve the monotony of close study of the text. These as well as the text illustrations draw largely from manufacturer's catalogues and similar sources.

It is manifestly probable, when the bulk of the work and the diversity of its contents are considered, that its publishers should have a fuller idea of its merits than we can derive from the limited time available for its review. We give, therefore, without comment on our part, the opinion passed by the publishers themselves: "The practical value of the work as a whole can hardly be questioned."

TRANSACTIONS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Vol. XXII., July to December, 1903. New York: American Institute of Electrical Engineers, 95 Liberty St. Cloth; 6 x 9 ins.; pp. 804; with many illustrations in the text.

It is regrettable that technical society proceedings of two years ago can only now reach publication in volume form. In the present case the delay is the more unfortunate because the volume contains an exceptional amount of valuable matter. The following record of titles of papers and addresses which with their discussions are contained in the volume may be of interest.

Presidential Address, by Mr. C. F. Scott; "Energy Transformations in the Synchronous Converter," by Prof. W. S. Franklin; "Commercial Alternator Design," by W. L. Waters; "Institute Branch Meetings, Their Organization, Development and Influence," by C. W. Rice; "Development and Application of the Cooper Hewitt Mercury Vapor Lamp," by M. v. Recklinghausen and P. H. Thomas; "High-Speed Electric Railway Problems," by A. H. Armstrong; "Storage Battery Industrial Locomotives," by F. L. Sessions; "Predetermination in Railway Work," by F. W. Carter; "Interurban Car Tests," by Prof. W. E. Goldsborough and P. E. Fansler; "Some Recommendations Concerning Electrical and Mechanical Specifications of Trolley-Line Insulators," by Prof. S. Sheldon and J. D. Kelley; "The Storage Battery in Substations," by Prof. W. E. Goldsborough and P. E. Fansler; "Some Notes on the Operation of Railway Motors in Service," by C. Renshaw; "Reverse-Current Circuit Breakers and the Protection of Transmission Lines," by L. Wilson; "Methods of Bringing High-Tension Conductors into Buildings," by C. E. Skinner; "The Grounded Wire as a Protection against Lightning," by R. D. Mershon; "The Testing of Electrical Apparatus for Dielectric Strength," by P. H. Thomas; "Choice of Frequency for Very Long Lines," by P. M. Lincoln; "Y or Delta Connection of Transformers," by F. O. Blackwell; "Electric Cables for High-Voltage Service," by H. W. Fisher; "The Operation and Maintenance of High-Tension Underground Systems," by P. Torchio; "The Use of Automatic Means for Disconnecting Disabled Apparatus," by H. G. Stott; "The Factors which Affect the Energy Losses in Armature Cores," by J. W. Esterline and C. J. Reid; "Central Station Economies," by Prof. W. E. Goldsborough and P. E. Fansler; "The Electrical Equipment of a Gold Dredge," by R. S. Montagu; "The Legalized Standard of Electromotive Force," by Prof. H. S. Carhart; "Magnetic Units," by Prof. A. E. Kennelly; "The Cathode-Ray Alternating-Current Wave Indicator," by Prof. H. J. Ryan; "Some Notes on Certain Underground Hoisting Problems on the Witwatersrand," by A. W. K. Peirce; "The Teaching of Physics to Engineering Students," by Prof. W. S. Franklin; "The Problems that Are Facing the Electrical Engineer of To-day, and the Qualities of Mind and Character which Are Needed to Meet Them," by J. G. White; "The Proper Qualifications of Electrical Engineering School Graduates, from the Telephone Engineer's Standpoint," by B. Gherardi, Jr.; "The Proper Qualifications of Electrical Engineering School Graduates, from the Manufacturer's Standpoint," by L. A. Osborne; "The Typical College Courses Dealing with the Professional and Theoretical Phases of Electrical Engineering," by Prof. D. C. Jackson; "Engineering English," by T. J. Johnston; "Training an Artist in the Forces of Nature," by E. H. Mullin; "An Efficient High Pressure Water Power Transmission Plant," by George J. Henry, Jr., and Prof. J. N. Le Conte; "Electric Motors for Centrifugal Pumps and Fans," by A. J. Bowie, Jr.; "The Conditions Governing the Rise of Temperature of Electric Railway Motors in Service," by C. T. Hutchinson; "A Graphic Recording Ammeter," by A. H. Armstrong; "The Electrical Conductivity of Commercial Copper," by L. Addicks; "The Comparative Behavior of Floating and Booster-Controlled Batteries on Fluctuating Loads," by L. Lyndon; "Overhead High-Tension Distributing Systems in Suburban Districts," by George H. Lukes; "Automatic Apparatus for Regulating Generator and Feeder Potentials," by E. J. Bechtel; "Safeguards and Regulations in Operation of Overhead Distributing Systems," by W. C. L. Eglin; "Gas Power for Central Stations," by J. R. Bibbins.

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Living Plants and Electrical Oscillations.

ON THE ABSORPTION OF ELECTROMAGNETIC WAVES BY LIVING VEGETABLE ORGANISMS.—By George O. Squier, Ph. D., Major, Signal Corps, U. S. A. Reprinted from Major-General Arthur MacArthur's report to the War Department on the Military Manœuvres in the Pacific Division, 1904. San Francisco, Cal.: Address the Author. Paper; 7 × 10 ins.; pp. 29; half-tone plates and figures in the text.

Six papers, each of interest in itself and in relation to the others, make up this pamphlet. They have both practical and theoretical bearing, although they represent only beginnings of experimentation in the several special fields most directly concerned.

The introduction reports that it has been found that in military telephone lines a good ground connection may be had by driving a nail into the trunk of a tree. In fact, very often this gives a much better ground than a buried ground plate, especially in dry districts; the tree ground is of course very much cheaper and easier to make than the other. The next paper describes experiments made to determine whether living trees could be used as air wires for wireless receiving. It was found that they gave very good results even with relatively crude receiving apparatus; the trunk below the first large branches seems to be the effective receiving conductor, and a wire attached to a nail driven at this point, and leading thence through the receiving instrument either to a nail driven in the tree at the base or to a spike driven in the ground some distance away, impresses the received potential wave upon the receiver instrument. The third paper describes a simplified field apparatus for military wireless telegraphy, though this is admittedly only for short distance work, being dependent upon battery power. The fourth paper relates observations of electromotive force, in a growing tree, between a point at the base of the tree and a point 25 ft. higher. The periods 6-9 a. m., 1-4 and 6-9 p. m. were the times of greatest potential, the upper point being the positive. The fifth paper describes an experiment made to learn whether induced currents flowed in the trees and ground along a high-tension power transmission line. By attaching a telephone to two points in the trunk of a tree within 100 ft. of the Yuba County transmission line in California, a loud and clear note was heard in the telephone, corresponding to the line frequency, 60 cycles per second. Similarly currents were found flowing in the ground, on a bare meadow along the line, the current flow being parallel to the transmission line. The vegetation along the line shows no observable effects, deleterious or otherwise, of the currents which have been flowing in it for the several years during which the line has been in operation. The sixth and last paper reports that oscillatory currents can be sent with living plants (in pots, on an insulating glass plate) as electrodes. Brush and spark discharges are obtainable, and the spark discharges may be examined spectroscopically. Spark discharges seem to kill off the leaves from which they emerge, while brush discharges have no perceptible effect on the growth.

An Elementary Text-Book on Microscopy.

ELEMENTS OF APPLIED MICROSCOPY.—A Text-Book for Beginners. By Charles Edward Amory Winslow, Instructor in Industrial Microscopy and Sanitary Biology in the Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 × 7½ ins.; pp. 183; 60 figures in the text. $1.50.

Few books are so well characterized by their titles as is the present one. The book presents the elements of miscroscopic study, and only the elements. Apparently all portions of the subject are discussed in equal simplicity, and the author has not yielded to the temptation to wander off in this or that interesting avenue of study, a thing which is so common in elementary texts, and which always has the effect of taking space from the necessary mention of other parts of the subject.

Mr. Winslow's text is practical. A reading of it gives a clear picture of the construction, use and functions of the miscroscope, and of its varied fields of service in technology and applied science. Such a general picture, when painted with sufficient illustrative detail (as in the present case), is an invaluable base on which fuller and more specific study can be founded. "Elements" having the purpose to present such a picture are necessary in nearly every branch of industry or study; applicants to the place are available in many branches; really suitable ones are very rare.

The restriction of the work to applied microscopy is eminently commendable. The microscope is many-sided. To the physicist it is a physical instrument. To the biologist, the mineralogist and many other students of science it is an everyday tool. In the general fields of either semi-scientific or purely industrial study, it is an aid which in one case may be merely a valuable help and in another may be an indispensable appliance for analysis or for test. Neither physicist nor biologist require an Elements of the Microscope. But the large and increasing number who use (or might use) it in the third field just noted have need for such a work. The abundant references to larger and more special works enable them to follow the subject in more detail after the general view has been obtained.

A bare list of the chapter headings will suffice to give an idea of the scope of the book: Function and parts of the microscope (22 pp.); Manipulation of the microscope (15 pp.); The mounting and preparation of objects for the microscope (14 pp.); Micrometry, and the camera-lucida (6 pp.); The microscopy of the common starches (11 pp); Foods and Drugs and their Adulterants (11 pp.); The examination of textile fibers (15 pp.); The microscopy of paper (9 pp.); The microscope in medicine and sanitation (22 pp.); Forensic microscopy (15 pp.); Microchemistry (12 pp.); Petrography and metallography (16 pp).

A New Treatise on Trusts.

TRUSTS, POOLS AND CORPORATIONS.—Edited with an Introduction by William Z. Ripley, Ph. D., Professor of Economics, Harvard University. New York and Boston: Ginn & Co. Cloth; 6 × 9 ins.; pp. xxx. + 427. $1.80.

While this book is for the most part a compilation of papers previously published, it is none the less an important and valuable contribution to economic literature. It has been written chiefly for use by students in University courses on economics; but it can be read with great profit by bankers, investors, engineers and in general any one desiring accurate information concerning recent history in the making—and breaking—of trusts.

The average intelligent business man doubtless considers himself well informed concerning the history of the United States Steel Corporation, the Asphalt swindle, the Shipbuilding scandal, and other malodorous doings that have ruined the reputation of dozens of "frenzied financiers" during the past half dozen year, and have made a million men poorer than a precious few might become enormously wealthy. But if he asks himself how he obtained his knowledge of the doings of these trusts he will find that it was solely from the fragmentary accounts published day by day in the newspapers, with an occasional article in a popular magazine. The ideas gained in this way are certain to be inaccurate and often warped by prejudice.

In this book, however, a connected history is given of a number of the most prominent trust organizations and the frauds and scandals which have marked their course are plainly pointed out. The author says in his preface:

> One motive in the preparation of this volume has been the hope that it might contribute toward a crystallization of public opinion favoring a reasonable policy of public control over monopolistic and corporate enterprises. The general reader and the legislator, in the mass of loose generalizations upon this topic, can scarcely be expected to follow publications in the technical economic journals. Such articles, unswayed as they should be by selfish interests and personal prejudice, nevertheless are the main ones which may safely be relied upon in the formation of a final judgment. By gathering together in convenient form this series of papers and documents, it is confidently hoped that progress toward the solution of one of our most troublesome public questions may be in some slight degree facilitated.

Among the most valuable chapters in the book are those which set forth the German law governing incorporated companies and the new English Corporation Act of 1900. The contrast is great between these and the state incorporation

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laws under which our American trusts have been nurtured.

In the introduction the author well says: "So far as individual repressive action by the separate states is concerned, the limit of legislative activity has about been reached. * * * * It becomes increasingly apparent that all effective remedies must be applied by the Federal Government." The closing chapter of the book is a critical review of recent literature on the subject of trusts by Chas. J. Bullock, of Harvard University, which is particularly instructive and interesting to one who desires a concensus of the best opinion as to the chief features of the trust problem.

We cannot take space here to enumerate the different subjects treated in all the chapters of the book; but one in particular, on public service corporations strikes us as particularly useful to engineers engaged in the appraisal of waterworks, gas works, etc., or as experts in litigation over such matters.

How to Form a Company.

A MANUAL OF CORPORATE ORGANIZATION.—Containing Information, Directions and Suggestions Relating to the Incorporation of Enterprises. By Thomas Conyngton, of the New York Bar, Author of "A Manual of Corporate Management." New York: The Ronald Press. Buckram or sheep; 6 × 9 ins.; pp. 352. Buckram, $2.70; sheep, $3.20.

While this book is doubtless intended chiefly for the legal profession, it is one which may be read to advantage by any layman interested in corporations and their management, and that includes a very large proportion of the men engaged in active business at the present day. More and more it is becoming the rule to substitute the corporate power of organization for the firm or partnership, even in the case of business operations of very modest proportions. This book makes clear the steps to be taken in the organization of a corporation, and answers the questions which are certain to occur to anyone proposing the formation of a company.

The scope of the book may be illustrated by quoting the titles of some of the chapters. Chapter II. Subscription Lists and Contracts. IV. Where to Incorporate. V. Cost of Incorporation. VIII. Preferred Stock. X. Treasury Stock. XIV. The Corporate Name. XVIII. The Board of Directors. XXI. Amendment of Charter. XXVII. Officers. XXVIII. Dividends and Finance. XXXIII. Concerning Promoters. XXXIV. Underwriting. XXXVII. Protecting an Inventor. XXVIII. Incorporating a Partnership. XL. Industrial Combinations. XLV. Voting Trust Agreements.

It is not, of course, the purpose of this book to enable the layman to dispense with the services of an attorney in incorporating a company any more than it is the purpose of a treatise on engineering to enable those who read it to construct the works it describes without the aid of an engineer. The treatise will in either case enable the services of either lawyer or engineer to be utilized to better advantage.

The book is very well written, and is everywhere so clear and non-technical that it can be read and understood by any business man. We can highly recommend it as a useful guide to anyone engaging in the organization of a corporation.

Railway Regulation in Illinois.

ILLINOIS RAILWAY LEGISLATION AND COMMISSION CONTROL SINCE 1870.—The University Studies, No. 6, University of Illinois Bulletin No. 12. By Joseph Hinckley Gordon, A. M. With an introduction by M. B. Hammond, Ph. D. Urbana, Ill.: University Press. Paper; 7 × 10 ins.; pp. 81.

THE GRANGER MOVEMENT IN ILLINOIS.—By A. E. Paine. Bulletin of the University of Illinois. Urbana, Ill.: University Press. Paper; 7 × 10 ins.; pp. 50. 35 cts.

It appears from a note prefacing the first of these bulletins that during 1900-01 the advanced students in the economic seminary devoted themselves to a study of the railway development of Illinois, under the direction of Professor Hammond, and among the work done was the preparation of this essay by Mr. Gordon. The public dissatisfaction over the rate-making methods of the railways led to the adoption of the government regulation system by the constitutional convention of 1870. In 1872, when the corn crop of the State was very great, the railways raised their rates to what was considered an exorbitant amount, and attempts to enforce the law at once led to litigation, with the result that the courts held that the State had a right to regulate rates. In 1873 the law was amended to include both passenger and freight rates, which led to further litigation; but in 1876 the courts finally upheld the position taken by the State. In 1891 an act was passed giving the Railway Commission jurisdiction over railway grade crossings. One chapter of the essay or pamphlet reviews the development of railway construction and consolidation from 1870 to 1900.

The second pamphlet reviews the growth of the organizations known as granges, or farmers' clubs, and then describes the fierce trial of strength between the grangers (or farmers) and the railways over the question of railway rates. But the grangers were powerful enough to carry through the legislature in 1871 a bill "to establish a reasonable maximum rate of charges for the transportation of passengers on the railways of this State." The litigation which followed is a matter of history, and is reviewed; it ended in the endorsement by the courts of the principle of regulation of railways by the State. We quote a closing paragraph, as follows:

> It may be said of the attitude of the railways that while there is little question that many of the demands of the Illinois grangers were decidedly unreasonable, and some of their methods forcible and illegal, yet this unreasonableness was made an excuse for opposition to many demands which were reasonable. In the main, the granger principles were sound and the results of the movement beneficial; for it has convinced the railway corporations that railways, to be successful, must be operated in accordance with the demands of their patrons, and that it is only a question of time when flagrant abuses affecting a large number of people must be remedied.

PROCEEDINGS OF THE ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.—Published by the Association. Secretary, S. F. Patterson, Concord, N. H. Paper; 6 × 9 ins.; pp. 333; illustrated.

This is the report of the proceedings of the 14th annual convention, held at Chicago in October, 1904. The principal papers and reports are as follows: (1) The best form of traveler for erecting steel bridges of spans up to 200 ft; (2) Use of concrete under bridge bed plates and turntables; (3) Care of trestles while being filled; (4) Engine-house construction; (5) Filling ice houses and conveying ice to refrigerator cars; (6) Steam hammers and drop hammers for pile drivers; (7) Record blanks for buildings and water tanks; (8) Doors for freight and engine houses; (9) Preserving timber and piles; (10) Protecting overhead structures from gases and blasts of locomotives; (11) Filling track tanks; (12) Cleanliness and decoration of station buildings and grounds.

HOW TO HANDLE FREIGHT.—By R. C. Richards, General Claim Agent, Chicago & Northwestern Ry. Published by the author. Cloth; 4¾ × 7¼ ins.; pp. 67.

This is a reprint of an address delivered before meetings of the railway company's agents and employees in various towns. The author shows that in the six years, 1898 to 1904, the company's freight earnings increased only 40%, but the number of claims increased 400%, freight lost increased 700%, freight damaged increased 400%, and the total amount paid for claims increased 470%. The address shows how and why the claims increase, the main reason being carelessness and neglect of orders. It urges the men to look out for the interests of the company which pays them as they would for their own interests. The author presses home the lesson, that applies to many things besides handling freight, that "it takes less time to learn to do a thing right than it does to explain why you did it wrong." The address is written in a breezy and conversational style, and makes interesting reading.

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U. S. COAST AND GEODETIC SURVEY.—Report of the Superintendent, Showing the Progress of the Work from July 1, 1903, to June 30, 1904. Washington, D. C.: Pub. Doc. Cloth; 9 × 12 ins.; pp. 774; 52 illustrations in the text and four maps in pocket.

The report of Superintendent O. H. Tittmann, of the Coast and Geodetic Survey, for 1904, practically covers the area of the United States and all its island possessions. In Alaska the work done includes the continuation of the survey of Prince William Sound, the survey of Controller Bay and a deep-sea examination from the Strait of Juan de Fuca to Prince William Sound, preliminary to the laying of a deep-sea cable between Seattle and Valdez. In Porto Rico the work relates generally to bays and harbors and off-shore waters. In the Philippine Archipelago the Insular Government has cooperated, and 21 charts have been prepared for publication. The reconnaissance for the primary triangulation along the 98th meridian has been completed to the Canadian boundary, and this work has been connected with the triangulation of the Mississippi River Commission.

Under the head of magnetic work, the report includes a table of results of the magnetic declinations, dip and intensity of force, on land and sea, as observed during the year. This is supplemented by a full description of the magnetic stations occupied and meridian lines observed. A new feature is the inclusion of the observations of the three magnetic elements at sea. The table contains the magnetic results at 384 land stations in our 24 states and territories and two foreign countries, and 52 sea results in the Atlantic and Pacific Oceans. The methods and instruments used are described in detail.

One of the astronomical events of the year was the determination of the longitude of Manila from San Francisco; thus completing the first longitude circuit of the earth. This achievement is here fully described, and it is very interesting to note that the results of the determination from the

eastward and westward only differ 0.006 sec., or about 8.8 ft.

Appendix No. 5 treats in full of the third attempt at representing the tide for the world at large, the first having been made by Whewell and the second by Berghaus. The results of the Precise Leveling operations for the year are shown in Appendices Nos. 6 and 7. These extend the precise level net 600 miles westward—to Red Desert, Wyoming, to Owyhee in Idaho, and south to Seguin, Texas. New methods have been introduced for supporting the level rod. A recording transit micrometer has been for the first time used in the telegraphic longitude determinations, and this is described in Appendix 8.

We have also the results of all triangulation in California, south of the latitude of Monterey Bay. These results, in compact and convenient form, give all the information in regard to this triangulation that would be useful to the engineer or surveyor. The location of more than 1,300 points are accurately fixed by this triangulation.

Generating Machines for Cutting Gears.

THE ART OF GENERATING GEAR-TEETH.—By Howard A. Coombs. New York: D. Van Nostrand Co. Boards; 4 × 6 ins.; pp. 129; 37 figures, mostly in the text. 50 cts.

This little book, which is one of Van Nostrand's Science Series, is a reprint of a series of articles that originally appeared in "The American Machinist." It is a review of what has been accomplished in the invention and construction of gear-cutting machines, the review being confined to those classes of gear-cutting machines that "generate" the tooth curves, in contradistinction to those machines that form the tooth by the use of cutters or templates previously shaped to the contour of the tooth. The book is well written, and written in such a manner that anyone can follow the text—in a word, it is not too technical even for the layman. The title might have been improved by calling the book. Generating-Machines for Cutting Gears.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Vol. XXV., 1904. New York: The Society, 12 West 31st St. Half leather; 6 × 9 ins.; pp. 1,155; with many plates and illustrations in the text.

The contents of this volume are:

"Slide Rules for the Machine Shop as a Part of the Taylor System of Management," by C. G. Barth; "Modifying Systems of Management," by H. L. Gantt; "Is Anything the Matter with Piecework?" by F. Richards; "Suggestions for Shop Construction," by F. A. Scheffler; "What Are the New Machine Tools to Be?" by Prof. J. E. Sweet; "Air Motors and Air Hammers—Apparatus and Methods for Testing," by M. H. Wickhorst; "A Method for Determining Rates and Prices for Electric Power," by F. B. Perry; "Improvement in Valve-Motion of Duplex Air Compressors," by S. H. Bunnell; "Tests of a Direct-Connected 8-ft. Fan and Engine," by E. S. Farwell; "A Series Distilling Apparatus of High Efficiency," by Prof. W. F. M. Goss; "The Pressure-Temperature Curve of Sulphurous Anhydride," by E. F. Miller; "The Pitot Tube," by W. B. Gregory; "Construction and Efficiency of a Fleming Four-Valve Engine," by B. T. Allen; "A Compact Gas Engine of Beam Type," by C. H. Morgan; "Tests of a Compound Engine Using Superheated Steam," by Prof. D. S. Jacobus; "Standard Unit of Refrigeration," by J. C. Bertsch; "Ordnance for the Land Service," by Major R. Birnie, U. S. A.; "Use of Superheated Steam and of Reheaters in Compound Engines of Large Size," by L. S. Marks; "Commercial Gas Engine Testing and Proposed Standard of Comparison," by W. P. Flint; "Road Tests of Consolidation Freight Locomotives," by Prof. E. A. Hitchcock; "Appendix IV. to VIth. Report of the Alloys Research Committee, Effects of Strain and of Annealing," by Wm. Campbell; "Experiments with a Lathe-Tool Dynamometer," by J. T. Nicolson; "Power Plant of the Tall Office Building," by J. H. Wells; "Some Theoretical and Practical Considerations in Steam Turbine Work," by F. Hodgkinson; "Different Applications of Steam Turbines," by A. Rateau; "Locomotive Testing Plants," by Prof. W. F. M. Goss; "A Rational Basis for Wages," by H. Emerson; "Cast Iron, Strength, Composition, Specifications," by W. J. Keep; "Potential Efficiency of Prime Movers," by Prof. C. V. Kerr; "Middlesborough Dock Electric and Hydraulic Power Plant," by V. L. Raven; "Refuse Destruction by Burning, and the Utilization of Heat Generated," by C. N. Russell; "Power Plant of Tall Office Buildings," by R. P. Bolton; "The Steam Turbine in Modern Engineering," by W. L. R. Emmet; "The De Laval Steam Turbine," by E. S. Lea and E. Meden; "Burning of Town Refuse," by G. Watson; "Robert Henry Thurston, a Memorial," by Prof. F. R. Hutton.

BULLETIN OF THE BUREAU OF STANDARDS.—Vol. I., No. 2, Issued February 1, 1905, by the Bureau of Standards (S. W. Stratton, Director), Department of Commerce and Labor, Washington, D. C. Paper; 7 × 10 ins.; pp. 289; illustrated.

This second issue of the "Bulletin" follows out the promise of the first issue in bringing accounts of work leading to better methods or more simple and accurate procedure in standardizing and calibrating. In the plan of organization of the Bureau, and in its work hitherto, it is clear that electrical measurements are its most important single object. This is confirmed in the present issue, which contains two electrical and one semi-electrical paper out of five. All five of these papers are of commendable precision and detail, and constitute lasting contributions to physical practice. They are: "The Absolute Measurement of Inductance" and "The Absolute Measurement of Capacity," both by Messrs. E. B. Rosa and F. W. Grover; "Optical Pyrometry," an excellent analytical review of the subject, by Messrs. C. W. Waidner and G. K. Burgess; "The Theory of the Matthews and the Russell-Leonard Photometers," by Mr. E. P. Hyde; and "The Testing of Clinical Thermometers," by Messrs. C. W. Waidner and L. A. Fischer.

The paper on "Optical Pyrometry," by Messrs. Waidner and Burgess, has also been issued by the Bureau of Standards as a separate pamphlet (7 × 10 ins.; pp. 66.)

STRUCTURAL DESIGNERS' HANDBOOK

By WILLIAM FRY SCOTT

Structural Engineer, Mem. Am. Soc. for Testing Materials.

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Chapter I.—Beams (Span, Cross-Section, Section Moment, Unit Stress, Manner of Support, Deflection, End Reaction, Buckling of Compression Flange, Loads on Beams, Conventional Methods of Loads on Floor Girders and on Grillage Beams). Chapter II.—Columns (Concentric Load, Eccentric Loads).

Part II. Beamwork.

Chapter III.—Floor Framing (Utility of Diagram, Diagrams 1 to 22, giving Allowable Load, Spacing, Span for I-Beams, Angles and Tees, and for Reducing the Value of Concentrated Load to Equivalent Uniform Load; Tables 1 to 15, giving Percentage of Allowable Load, Spacing and End Reaction for I-Beams). Chapter IV.—Spandrel Beams (Diagram 23, for Giving Equivalent Value for Load Concentrated at Middle of Span for Value of Load Concentrated at Any Other Point; Diagrams 24, 25 and 26, for Allowable Loads on Standard and Special I-Beams and Channels). Chapter V.—Grillage Beams (Footings, Design, Bending, Buckling; Diagram 27, for giving Size, Weight and Spacing of I-Beams in Grillage Footings). Chapter VI.—End Reactions (Design and Sizes of Standard Connection Angles and Bearing Plates; Table 16, for Maximum Allowable End Reaction or Connection Angles and Relative Values of Several Sizes of Rivets; Diagram 28, for Values of Rivets in Connection Angles and Areas for Bearing Plates; Diagram 29, for Thickness of Beam Plates of Cast-Iron, Wrought-Iron or Steel).

Part III. Columns and Truss Members.

Chapter VII.—Steel Columns (Ratio of Slenderness; Diagrams 30 and 31, for Radius of Gyration of Column Sections of Wood, Cast-Iron, Steel and of Built-up Sections; Diagram 32, for Ratio of Slenderness; Diagram 33, for Safe Loads on Steel Columns as called for by New York Building Code; Diagram 34, for Eccentric Loading on Columns). Chapter VIII.—Tables (Tables 17 to 24, giving Properties of Single and Built-up Steel Shapes for I-Beams, Channels, Angles, Tees, Zees and Flats for Use in Columns, Beams and Trusses; Table 25, Weights of Flat Rolled Steel). Chapter IX.—Cast-Iron Columns (Diagrams 35 and 36, Safe Loads on Cast-Iron Columns recommended by New York Building Code and by the author; Tables 26 to 30, Weight and Thickness of Metal of Cast-Iron Column Sections; Table 31, Weight and Thickness of Metal of Cast-Iron Gas Pipe).

Part IV. Miscellaneous.

Chapter X.—Loads (Diagram 37, for Weight of Steel Required in Floors where Loads are Minimum; Diagram 38, for Weight of Steel where Loads are Maximum; Diagram 39, for Weight of Joists per Square Foot of Floor; Floor Arches, Flooring Material, Partitions, Brick Walls, Live Loads on Floors and on Footings, Wind Pressure on Buildings). Chapter IX.—Unit Stresses (Safe Loads on Masonry Work, Strength of Columns, Working Stresses, Compression, Tension, Shear, Safe Extreme Fiber Stress, Bearing Capacity of Soil). Chapter XII.—Brick Walls (Diagram 40, giving Thickness and Weight of Walls for Skeleton Structures, Warehouses or Dwelling Houses, according to New York Building Code). Chapter XIII.—German, Belgian and English I-Beams (Tables 32 to 34, Properties of German, Belgian and English I-Beams). Chapter XIV.—Flexural Efficiency of I-Beams and Channels (Diagram 41, giving Relative Flexural Efficiency of I-Beams and Channels per Pound of Steel). Chapter XV.—Bases and Lintels of Cast-Iron (Methods of Design; Diagram 42, giving Minimum Thickness for Bottom Plate of Cast-Iron Shoes). Chapter XVI.—Wooden Beams and Posts (Diagrams 43 to 51, giving Safe Loads on Joists and Girders of White Pine, Spruce, Chestnut, Yellow Pine and Locust, and on Posts of White Pine, White Oak and Yellow Pine).

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THE ENGINEERING NEWS PUBLISHING CO., New York.

REPORT OF THE ILLINOIS GOOD ROADS COMMISSION.—Pub. Doc.; issued by the Commission, Springfield, Ill. Paper; 6 × 9 ins.; pp. 56.

This Commission was appointed two years ago, and has now made its first report. It shows that in 1903 there were about 101,000 miles of wagon roads (exclusive of streets in cities, towns and villages), while the tax raised for road and bridge purposes was $3,792,080, besides about $540,600 paid to road officials out of the town funds. A statement prepared by Prof. Crantz, State Geologist, shows the distribution of road building material. Roads surfaced with stone and gravel aggregate 3,495 miles, the reported cost of which varies very greatly: from $180 to $4,000 per mile for gravel, and from $480 to $6,000 per mile for stone. The report discusses drainage, convict labor, State aid, and suggests that in Illinois the State should pay 50% and the county and township 25% each of the cost of improved roads. The report occupies 26 pages, and is followed by notes on road legislation in other States, traction tests on different kinds of roads, and extracts from addresses on the subject of good roads.

Literary Magazines.

Readers of Engineering News living far from New York City, who see the March "Century," may be interested to look at Joseph Pennell's etching of the St. Paul Building, in which the offices of Engineering News have been located for ten years past. The picture shows the building from the most favorable view point to display its architecture, of which the most notable feature doubtless is the heavy belt courses of the walls at alternate stories, which have the effect, at a distance, of making the window openings appear to be double the height and half the number that actually exist. From a scientific standpoint the most interesting article in the "Century" by all odds is the account of the work of Luther Burbank, the horticultural expert, who has performed such wonderful feats in the development of new species of plants and fruits as have perhaps never been equalled. The most wonderful feat of all, according to the writer, is the production of a species of edible cactus which will grow in the desert regions where no other plants can survive and will produce great amounts of rich food. At the same time it has been made so hardy that it may be grown in the temperate zone and in humid regions as well as in its native habitat. If all these claims are substantiated, it would be difficult to set a limit to the economic and social effects that may result from the discovery. Among the other results of Mr. Burbank's creative genius are such anomalies as white blackberries and blackberry bushes without thorns and such novelties as the Shasta daisy, a new and fragrant larkspur, a fragrant dahlia, and a walnut tree which grows more rapidly than any other tree in the temperate zone.

Still another "Century" article deserving notice here is an account of the work of Japanese engineers in conducting the siege operations at Port Arthur.

In "Everybody's" for March, Mr. Thomas Lawson begins the story of the organization of the Amalgamated Copper combination. His articles in preceding issues of this magazine have dealt with the evil machinations in connection with that malodorous concern known as Bay State Gas. Mr. Lawson opens this number by assuring the reader that "the crimes of Amalgamated are to the delinquencies of Bay State Gas as the screaming of eagles to the chirping of crickets."

A notable article in the "Review of Reviews" for March is an interesting description of the municipal improvements now under way at Washington. Over $17,000,000 worth of municipal improvements are now in progress in that city and a vast amount of work in the shape of new government buildings is also planned. The same magazine also contains a description of some recent novel types of life boats.

The March "World's Work" has a finely illustrated paper describing the forbidden city of Lhassa and the journey of the British expedition thither a year ago, written by a London "Times" correspondent who accompanied the expedition. It is a curious illustration of the penetrative power of commerce that in this city which has hitherto been a sealed mystery and which no one from the occidental world has ever entered before, Col. Younghusband's party found in the house which was given up for their occupancy a small pendulum clock made in Ansonia, Conn. The same magazine has an excellent paper entitled "Why English Railroads are Safe," which we especially commend to those more zealous than wise defenders of American railway practice who have within the past few months tried to cast doubt on the accident statistics compiled by the Interstate Commerce Commission. We may note here only that while in 1903 there were 6,167 collisions and 4,476 derailments on American railways there were in the same year in England only 111 collisions and 80 derailments. The train miles run during the year in the two countries were 900 million miles in the United States and 400 million miles in England. Mr. Lawrence Lewis, in the same magazine, describes the work done under the direction of Mr. John C. Osgood and the late Julian A. Kebler for the social betterment of the 17,000 employees of the Colorado Fuel & Iron Co. There is also an excellent biographical account of Mr. Chas. M. Jacobs, the engineer of the Hudson River Tunnels.

In the March "North American Review" an excellent summary is given of the investigation carried out by the Merchant Marine Commission respecting the best plan for increasing the American carrying trade on the high seas. The author is Prof. Jos. W. Garner, of the University of Illinois, and his paper is the fairest statement upon this important topic that we have anywhere seen. "The Danger of Government Rate-Making" is discussed by President David Willcox of the Delaware & Hudson Co. in the same magazine.

Educational systems in Europe are discussed by Frank A. Vanderlip in the March "Scribner's" and he is full of praise for the technical, trade, and commercial schools of Germany. The French schools, on the other hand, he condemns for their cast-iron methods. In France the national government has entire control of the schools and the local community have absolutely nothing to say as to the operation of the educational system. As a result the French school system is a vast machine in which the pupils are made to memorize facts rather than taught to think for themselves.

Probably nine out of ten people in this country firmly hold to the opinion that the English and American systems of leaving the railway business in the hands of private corporations is far superior to the German and French system of State railway ownership and operation. It is so seldom that one sees any logical and temperate statement in favor of Government ownership of railways that we note with especial interest an article in the February "Contemporary Review" on the "Railways of Germany." At this time when talk of Government rate fixing is so much heard, it may be of interest to see how this is done on the German railways. The author says:

> The British Railways charge on freight "what the traffic will bear." A reliable guide to the freight charges does not exist in this country, and it could not be compiled for the freight charges per mile for identical goods and even on the same line vary in almost every town; besides, freights fluctuate constantly. . . . . The German tariff is of beautiful simplicity. The freight charges are uniform throughout the country and are fixed at an invariable amount per ton per mile. There are only a few classes of goods and every merchant has a little book by which the office boy can calculate in a moment the exact amount of the freight charges for any weight between any two stations.

Notwithstanding the fact that the German state railways were largely purchased from private owners at an exorbitant figure, they are paying so well that in 1900 the average earnings were 7% on the entire capitalization. As the state debt bears 3½% interest, the nation is making an enormous profit from the money which it borrowed to purchase the railways. In 1903 the net earning of German railways provided the entire interest and sinking fund requirements on the state debt of nearly $1,750,000,000 and returned besides over $50,000,000 to the national treasury.

Publications Received.

STEAM TURBINES.—With an Appendix on Gas Turbines and the Future of Heat Engines. By Dr. A. Stodola, Professor at the Polytechnikum in Zurich. Authorized Translation from the Second Enlarged and Revised German Edition, by Dr. Louis C. Loewenstein, Department of Mechanical Engineering, Lehigh University. New York: D. Van Nostrand Co. London: Archibald Constable & Co., Ltd. Cloth; 6½ × 9½ ins.; pp. xvi. + 434; 241 figures, mostly in the text, and three lithograph tables in pocket. $4.50 net.

THE STEAM ENGINE AND OTHER STEAM MOTORS.—A Text-Book for Engineering Colleges and a Treatise for Engineers. In Two Volumes. Vol. I.: The Thermodynamics and the Mechanics of the Engine. By Robert C. H. Heck, M. E., Assistant Professor of Mechanical Engineering, Lehigh University. New York: D. Van Nostrand Co. Cloth; 6½ × 9½ ins.; pp. 391; 190 figures and many tables in the text. $3.50 net.

A HANDBOOK FOR SUPERINTENDENTS OF CONSTRUCTION, ARCHITECTS, BUILDERS AND BUILDING INSPECTORS.—By H. G. Richey, Superintendent of Construction, U. S. Public Buildings; Author of "Richey's Guide and Assistant for Carpenters and Mechanics." New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Morocco; 4 × 7 ins.; pp. 744; 357 figures and many tables in the text. $4.00.

THE GRAPHIC METHODS BY INFLUENCE LINES FOR BRIDGE AND ROOF COMPUTATIONS.—By William H. Burr, C. E., Professor of Civil Engineering in Columbia University, M. Am. Soc. C. E., M. Inst. C. E.; and Myron S. Falk, Ph.D., Instructor in Civil Engineering in Columbia University, Jun. M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. 253; 158 figures in the text, and three folding plates. $3.00.

THE TEMPERATURE-ENTROPY DIAGRAM.—By Charles W. Berry, Instructor in Mechanical Engineering in the Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 × 7½ ins.; pp. xvi + 134; 49 figures in the text. $1.25.

LIVES OF THE ENGINEERS GEORGE AND ROBERT STEPHENSON.—By Samuel Smiles, Author of "Character," "Self-Help," etc. The Locomotive. London: John Murray. Cloth; 5 × 8 ins.; pp. xliv. + 466; seven plates and 68 line illustrations. 3s. 6d.; American price, $1.40.

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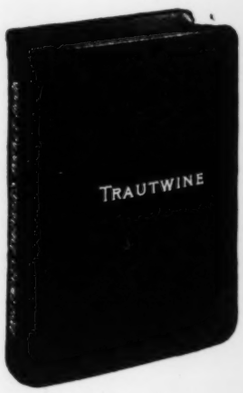

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